IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF DELAWARE

DELAWARE DISPLAY GROUP LLC and INNOVATIVE DISPLAY TECHNOLOGIES LLC,	§	PUBLIC VERSION
	§	**C.A. No. 13-cv-2109-RGA**
Plaintiffs,	§	**JURY TRIAL DEMANDED**
v.	§	[redacted]
LG ELECTRONICS, INC., LG ELECTRONICS U.S.A., INC., LG DISPLAY CO., LTD., and LG DISPLAY AMERICA, INC.,	§	
Defendants.		

PLAINTIFFS' MOTION FOR LEAVE TO FILE SECOND AMENDED COMPLAINT

Under Federal Rule of Civil Procedure 15(a)(2), Plaintiffs Delaware Display Group LLC and Innovative Display Technologies LLC (collectively, "Plaintiffs") respectfully move the Court for leave to file a Second Amended Complaint to plead allegations of willful infringement of the patents still in suit: U.S. Patent No. 7,434,974, U.S. Patent No. 7,537,370, U.S. Patent No. 7,914,196, and U.S. Patent No. 8,215,816, against Defendants LG Electronics, Inc., LG Electronics U.S.A., Inc., LG Display Co., Ltd., and LG Display America, Inc. (collectively, "LG").[1] A copy of the proposed Second Amended Complaint is attached hereto as Exhibit 1, and a redlined version of the Second Amended Complaint, highlighting the changes from the Second Amended Complaint, is attached hereto as Exhibit 2.

I. BACKGROUND

Plaintiffs filed this patent infringement action against LG on December 31, 2013. (D.I. 1.) Plaintiffs' original complaint alleged past and continuing infringement by LG as to eight of

[1] Pursuant to D. Del. LR 7.1.1, the parties discussed whether this motion could be filed unopposed, but Defendants did not agree and thus oppose this motion.

Plaintiffs' patents: U.S. Patent No. 6,755,547, U.S. Patent No. 7,300,194, U.S. Patent No. 7,384,177, U.S. Patent No. 7,404,660, U.S. Patent No. 7,434,974, U.S. Patent No. 7,537,370, U.S. Patent No. 7,914,196, and U.S. Patent No. 8,215,816. (Id.) Within its allegations of infringement, Plaintiffs asserted claims directed towards LG's making, using, offering to sell, and/or selling within and/or importing into the United States display products infringing Plaintiffs' patents. Additionally Plaintiffs included inducement allegations directed at LG's inducement of third-party manufacturers, distributors, importers and/or consumers that purchase or sell display products and have purchased LG's infringing products and third-party consumers which use and have used LG's infringing products. This Complaint did not allege willful infringement.

Pursuant to an agreed upon party stipulation, and later pursuant to the Court's direction, Plaintiffs dismissed without prejudice Plaintiffs' claims for infringement of U.S. Patent Nos. 6,755,547, 7,300,194, 7,384,177, 7,404,660, and 7,434,973. (D.I. 44 and D.I. 125, respectively.). For clarity, Plaintiffs' proposed Second Amended Complain removes the counts of infringement for any of those patents that remained in the previous complaint.

Plaintiffs have only sought to amend their Complaint one previous time to add allegations of infringement as to U.S. Patent No. 7,434,973 ("the '973 patent"). (D.I. 48.) The Court granted Plaintiffs leave to make this amendment and entered the First Amended Complaint on July 28, 2015. (D.I. 68.) As mentioned *supra*, the allegations regarding this added patent, the '973 patent, have been subsequently dismissed.

The Scheduling Order issued by the Court on September 2, 2014, is still in place and governs the parties' remaining deadlines. (D.I. 19.) Pursuant to this Scheduling Order, the deadline for all motions to amend pleadings to allege inequitable conduct and/or willfulness is

December 4, 2015. (Id.) Fact discovery is scheduled to close on December 4, 2015 (id.), although the parties are currently intend to move to extend that deadline. The deadline for filing case dispositive motions is June 3, 2016. (Id.) Trial is scheduled to commence on October 24, 2016. (Id.)

In accord with these deadlines, Plaintiffs now request leave to amend to plead allegations for LG's willful infringement of the patents still in suit: U.S. Patent No. 7,434,974, U.S. Patent No. 7,537,370, U.S. Patent No. 7,914,196, and U.S. Patent No. 8,215,816 (collectively "the patents-in-suit").

II. LEGAL STANDARD

Federal Rule of Civil Procedure 15(a) provides that after a responsive pleading has been filed, a party may amend its pleading only with the opposing party's written consent or by leave of court. Fed. R. Civ. P. 15(a)(2). "[L]eave to amend 'shall be freely given when justice so requires.'" *Foman v. Davis*, 371 U.S. 178, 182 (1962) (quoting Fed. R. Civ. P. 15(a)). The Third Circuit encourages a liberal approach to amendment of pleadings. *See Dole v. Arco*, 921 F.2d 484, 487 (3d Cir. 1990); *Bechtel v. Robinson*, 886 F.2d 644, 652 (3d Cir. 1989). Courts deny leave to amend only where there exists undue delay, bad faith, or dilatory motives on the part of the moving party, or where the amendment is futile or unfairly prejudicial to the non-moving party. *See Foman*, 371 U.S. at 182; *In re Burlington Coat Factory Secs. Litig.*, 114 F.3d 1410, 1434 (3d Cir. 1997).

III. ARGUMENT

Plaintiffs request leave to amend to aver allegations for LG's willful infringement of the patents still in suit: U.S. Patent No. 7,434,974, U.S. Patent No. 7,537,370, U.S. Patent No. 7,914,196, and U.S. Patent No. 8,215,816 (collectively "the patents-in-suit"). This request is

timely filed within the deadline for amending pleadings under the Court's Scheduling Order (D.I. 19), and is made in good faith without dilatory motives.

The factors considered in weighing a motion for leave to amend are well-settled: (1) whether the amendment has been unduly delayed; (2) whether the amendment would unfairly prejudice the non-moving party; (3) whether the amendment is brought for some improper purpose; and (4) whether the amendment is futile. *See Foman v. Davis,* 371 U.S. 178, 182 (1962).

None of the factors for overcoming this Circuit's standard that "leave to amend shall be freely given" apply here. First, there is no undue delay or dilatory motive behind Plaintiffs' proposed amendment. Plaintiff makes these amendments in in accordance with the deadline for amendments agreed to by the parties and ordered by the Court. (D.I. 19.) Filing within the deadline set forth in the scheduling order for amending pleadings generally precludes a finding of undue delay. *See Invensas Corp. v. Renesas Elecs. Corp*., C.A. No. 11-448-GMS-CJB, 2013 WL 1776112, at *3 (D. Del. Apr. 24, 2013) (granting plaintiffs motion to amend and finding no undue delay when plaintiffs filed on the last day set by the scheduling order for the filing of amendments to pleadings); *Butamax Advanced Biofuels LLC v. Gevo, Inc*., C.A. No. 11-54-SLR, 2012 WL 2365905, at *2 (D. Del. June 21, 2012) (holding that a motion to amend filed on the deadline for amended pleadings was "filed timely and, therefore, there can be no unfair prejudice to defendant").

Next, this amendment is not being brought for some improper purpose and LG will not be unfairly prejudiced if it is allowed. The willfulness allegations Plaintiffs seek leave to include are already known by LG. Specifically, they reflect the prior and continuing acts of LG and are

premised in part based upon documents discovered from LG and from the prior owners of the patents-in-suit through the discovery process in this case.

Finally, the allegations and their factual specificity in the Second Amended Complaint demonstrate this amendment is not futile. "An amendment is futile if it is frivolous, fails to state a claim upon which relief can be granted, or 'advances a claim or defense that is legally insufficient on its face.'" *Gelof v. Smith*, No. 11-483-LPS, 2012 WL 394741,*2 (D. Del. Feb. 3, 2012) (quoting *Koken v. GPC Int'l, Inc.*, 443 F. Supp. 2d 631, 634 (D. Del. 2006)). However, a "proposed amendment is not futile [where it] would withstand a motion to dismiss." *Free Speech Coal, Inc. v. Attorney Gen. of U.S.*, 677F.3d 519, 545 (3d Cir. 2012).

Seagate sets forth the two-prong analysis the Federal Circuit has mandated for establishing willful infringement. *See In re Seagate Tech.*, LLC, 497 F.3d 1360, 1371 (Fed. Cir. 2007). First, plaintiff must provide "clear and convincing evidence that the infringer acted despite an objectively high likelihood that its actions constituted infringement of a valid patent." *Id.* Second, plaintiff must show that the risk "was either known or so obvious that it should have been known to the accused infringer." *Id.*

Here, the Second Amended Complaint contains considerable factual detail describing the circumstances in which the patents-in-suit were called to the attention of LG. Specifically, it explains that LG was notified that its products were infringing the patents in suit at least as early as January 30, 2012, [redacted]

[redacted]. *Id.* at ¶ 34.

The proposed pleading alleges further factual support for its allegations of willful infringement based upon LG's actual knowledge from subsequent notice provided directly from [redacted] Specifically it explains that on February 8, 2013, [redacted] *See, e.g.* Exhibit 1 at ¶ 35.

The proposed Second Amended complaint also describes how LG was aware of the patents-in-suit based on its [redacted] *See, e.g. id.* at ¶¶ 37-38.

The proposed Second Amended complaint also discusses LG's continued awareness of its infringement of the patents-in-suit since the filing of the complaint in this case. *See, e.g. id.* at ¶ 39.

The proposed Second Amended complaint further describes that LG continues to infringe the patents-in-suit despite its failure to obtain institution of *inter partes review* of the asserted claims of the patents-in-suit despite numerous attempts. *See, e.g. id.* at ¶ 40.

The Second Amended Complaint contains allegations as to LG's reckless disregard of its own infringement and infringement by its customers and describes how LG, in spite of obtaining actual knowledge of the patents-in-suit, did then and continues now to infringe these patents. *Id.* at ¶ 41.

Plaintiffs' allegations are indistinguishable from the factual circumstances the Courts in this District regularly recognize as adequately stating a claim for willful infringement by demonstrating the requisite pre-suit knowledge and the objective recklessness of infringement.

In *Fairchild Semiconductor Corp. v. Power Integrations, Inc*., the court held that the disputed counterclaim adequately stated a claim for willful infringement where it alleged plaintiff's knowledge of the patent-in-suit, direct infringement by plaintiff's customers and that the plaintiff had knowledge of these infringing uses by its customers. 935 F. Supp. 2d 772, 778 (D. Del. 2013). *See also Courtesy Products L.L.C. v. Hamilton Beach Brands, Inc.*, No. CV 13-2012-SLR-SRF, 2015 WL 6159113, at *3 (D. Del. Oct. 20, 2015):

> Cases within this district have held that allegations of willful infringement are sufficiently pleaded when the complaint claims (1) knowledge of the patent-in-suit by the alleged infringer, (2) sales of the accused product to customers, and (3) knowledge that those customers will use the accused product for its infringing use.

Similarly, in S*t. Clair Intellectual Property Consultants, Inc. v. Hewlett-Packard Co.*, the court determined that the proposed amended complaint was not futile because the complaint adequately pleaded allegations of willful infringement by stating that defendant "deliberately infringed the Patents in Suit and acted recklessly and in disregard to the Patents in Suit in designing and making and selling" certain products, in addition to setting forth facts regarding the defendant's knowledge of the infringement. C.A. No. 10-425-LPS, 2012 WL 1134318, at *3 (D. Del. Mar. 28, 2012); s*ee also Walker Digital, LLC v. Facebook, Inc.*, 852 F. Supp.2d 559, 567-68 (D. Del. 2012) (finding pleading of willful infringement sufficient where the "amended complaint provides evidence that [the defendant] had pre-suit knowledge of the patents-in-suit due to [defendant's] interactions with [plaintiff's] representatives, which occurred before the original complaint was filed."); *compare Intellectual Ventures I LLC v. Toshiba Corp.*, 66 F. Supp. 3d 495, 500 (D. Del. 2014) ("holding notice of the infringement risk via the letter written

only one day before the complaint was filed does not constitute a showing of objective recklessness on the part of the defendants.")

Accordingly, the Court should recognize the Second Amended Complaint as adequately pleading willfulness and grant Plaintiffs leave to amend consistent with Rule 15(a)(2) and the Third Circuit's liberal approach to amendment of the pleadings.

WHEREFORE, Plaintiffs respectfully requests that the Court enter an Order granting Plaintiffs leave to file the attached Second Amended Complaint.

DATED: December 4, 2015

Respectfully submitted,

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FOR THE DISTRICT OF DELAWARE

DELAWARE DISPLAY GROUP LLC and INNOVATIVE DISPLAY TECHNOLOGIES LLC,	§	
	§	**C.A. No. 13-cv-2109-RGA**
Plaintiffs,	§	**JURY TRIAL DEMANDED**
v.	§	**FILED UNDER SEAL**
LG ELECTRONICS, INC.,	§	
LG ELECTRONICS U.S.A., INC.,	§	
LG DISPLAY CO., LTD., and	§	
LG DISPLAY AMERICA, INC.,	§	
Defendants.	§	

PLAINTIFFS' SECOND AMENDED COMPLAINT

Delaware Display Group LLC and Innovative Display Technologies LLC (collectively, "Plaintiffs") by and through their undersigned counsel, file this Second Amended Complaint against LG Electronics, Inc.; LG Electronics U.S.A., Inc.; LG Display Co., Ltd.; and LG Display America, Inc. (collectively, "LG")

THE PARTIES

1. Delaware Display Group LLC ("DDG") is a Delaware limited liability company with its principal place of business located at 2400 Dallas Parkway, Suite 200, Plano, Texas 75093.

2. Innovative Display Technologies LLC ("IDT") is a Texas limited liability company with its principal place of business located at 2400 Dallas Parkway, Suite 200, Plano, Texas 75093.

3. Upon information and belief, LG Electronics, Inc. ("LG Electronics") is a corporation in South Korea located at LG Twin Towers, 20, Yeouido-dong, Yeongdeungpo-gu, Seoul, 150-721, South Korea. Upon information and belief, LG Electronics may be served with

process in South Korea pursuant to the Hague Convention on the Service Abroad of Judicial and Extrajudicial Documents in Civil or Commercial Matters.

4. Upon information and belief, LG Electronics U.S.A., Inc. ("LG Electronics U.S.A.") is a Delaware Corporation with offices at 1000 Sylvan Avenue, Englewood Cliffs, New Jersey 07632. Upon information and belief, LG Electronics U.S.A. may be served with process by serving its registered agent, United States Corporation Company, 2711 Centerville Road, Suite 400, Wilmington, Delaware 19808. Upon information and belief, LG Electronics U.S.A. is a subsidiary of LG Electronics.

5. Upon information and belief, LG Display Co., Ltd. ("LG Display") is a corporation in South Korea located at LG U+ Bldg., Hangang-ro 3-ga, Yongsan-gu, Seoul, Korea. Upon information and belief, LG Display may be served with process in South Korea pursuant to the Hague Convention on the Service Abroad of Judicial and Extrajudicial Documents in Civil or Commercial Matters. Upon information and belief, LG Display is a subsidiary of LG Electronics.

6. Upon information and belief, LG Display America, Inc. ("LG Display America") is a California Corporation with its principal place of business at 2540 North First Street, Suite 400, San Jose, California 95131. Upon information and belief, LG Display America may be served with process by serving its Agent for Service, Dong Hoon Han, LG Display America, Inc., 2540 North First Street, Suite 400, San Jose, California 95131. Upon information and belief, LG Display America is a subsidiary of LG Display.

7. Upon information and belief, LG has conducted and regularly conducts business within this District, has purposefully availed itself of the privileges of conducting business in this District, and has sought protection and benefit from the laws of the State of Delaware.

JURISDICTION AND VENUE

8. This action arises under the Patent Laws of the United States, 35 U.S.C. § 1, *et seq.*, including 35 U.S.C. §§ 271, 281, 283, 284, and 285. This Court has subject matter jurisdiction over this case for patent infringement under 28 U.S.C. §§ 1331 and 1338(a).

9. As further detailed herein, this Court has personal jurisdiction over LG. LG is amenable to service of summons for this action. Furthermore, personal jurisdiction over LG in this action comports with due process. LG has conducted and regularly conducts business within the United States and this District. LG has purposefully availed itself of the privileges of conducting business in the United States and, more specifically, in this District. LG has sought protection and benefit from the laws of the State of Delaware by incorporating in the state of Delaware, incorporating a subsidiary in the State of Delaware, and/or by placing infringing products into the stream of commerce through an established distribution channel with the expectation and/or knowledge that they will be purchased by consumers in this District. Plaintiffs' causes of action arise directly from LG's business contacts and other activities in this District.

10. LG – directly or through intermediaries (including distributors, retailers, and others), subsidiaries, alter egos, and/or agents – ships, distributes, offers for sale, and/or sells its products in the United States and this District. LG has purposefully and voluntarily placed one or more of its infringing products, as described below, into the stream of commerce with the expectation and/or knowledge that they will be purchased by consumers in this District. LG knowingly and purposefully ships infringing products into and within this District through an established distribution channel. These infringing products have been and continue to be purchased by consumers in this District. Upon information and belief, LG has committed the tort of patent infringement in this District and/or has induced others to commit patent infringement in this District.

11. Venue is proper in this Court under 28 U.S.C. §§ 1391(b), (c), and (d), as well as 28 U.S.C. § 1400(b), in that LG is subject to personal jurisdiction in this District, and therefore is deemed to reside in this District for purposes of venue, and, upon information and belief, LG has committed acts within this judicial District giving rise to this action and does business in this District, including but not limited to making sales in this District, providing service and support to their respective customers in this District, and/or operating an interactive website that is available to persons in this District, which website advertises, markets, and/or offers for sale infringing products.

BACKGROUND

A. The Patents-In-Suit.

12. U.S. Patent No. 7,434,974 titled "Light Emitting Panel Assemblies" ("the '974 patent") was duly and legally issued by the U.S. Patent and Trademark Office on October 14, 2008, after full and fair examination. Jeffery R. Parker is the sole inventor listed on the '974 patent. A true and correct copy of the '974 patent is attached as **Exhibit A** and made a part hereof.

13. U.S. Patent No. 7,537,370 titled "Light Emitting Panel Assemblies" ("the '370 patent") was duly and legally issued by the U.S. Patent and Trademark Office on May 26, 2009, after full and fair examination. Jeffery R. Parker is the sole inventor listed on the '370 patent. A true and correct copy of the '370 patent is attached as **Exhibit B** and made a part hereof.

14. U.S. Patent No. 7,914,196 titled "Light Redirecting Film Systems Having Pattern of Variable Optical Elements" ("the '196 patent") was duly and legally issued by the U.S. Patent and Trademark Office on March 29, 2011, after full and fair examination. Jeffery R. Parker, Timothy A. McCollum, and Robert M. Ezell are the inventors listed on the '196 patent. A true and correct copy of the '196 patent is attached as **Exhibit C** and made a part hereof.

15. U.S. Patent No. 8,215,816 titled "Light Emitting Panel Assemblies" ("the '816 patent") was duly and legally issued by the U.S. Patent and Trademark Office on July 10, 2012, after full and fair examination. Jeffery R. Parker is the sole inventor listed on the '816 patent. A true and correct copy of the '816 patent is attached as **Exhibit D** and made a part hereof.

16. The '196 patent is referred to as the "DDG patent."

17. The '974 patent, the '370 patent, and the '816 patent are collectively referred to as the "IDT patents." Together, the "DDG patent" and the "IDT patents" are the "patents-in-suit."

18. On June 26, 2013, IDT was assigned all of the right, title, and interest in the IDT patents, including the exclusive right to sue and collect for its own use and benefit all claims for damages by reason of past infringement or use of the IDT patents.

19. On December 20, 2013, DDG was assigned all of the right, title, and interest in the DDG patent, including the exclusive right to sue and collect for its own use and benefit all claims for damages by reason of past infringement or use of the DDG patent.

20. The patents-in-suit all share the same ultimate parent patent, U.S. Patent No. 5,613,751. The patents-in-suit share inventors, subject matter, and claim terms. The accused products infringe the Patents-in-Suit based on the use of the same technology, *i.e.*, backlights for LCD displays. And IDT and DDG share a common corporate parent.

B. LG's Infringing Conduct.

21. Upon information and belief, LG makes, uses, offers to sell, and/or sells within, and/or imports into the United States display products that use the fundamental technologies covered by the patents-in-suit. Upon information and belief, the infringing display products include, but are not limited to, mobile phones, tablets, televisions, and monitors with an LCD. By way of example only, Plaintiffs identify the Optimus E970 mobile phone as an infringing product of the patents-in-suit.

22. By incorporating the fundamental inventions covered by the patents-in-suit, LG can make improved products, including but not limited to, products with longer displays, thinner displays, and/or displays with a higher light output, a more uniform light output, a lower power requirement, and/or a longer battery life.

23. Upon information and belief, third-party distributors purchase and have purchased LG's infringing display products for sale or importation into the United States, including this District. Upon information and belief, third-party consumers use and have used LG's infringing display products in the United States, including this District.

24. Upon information and belief, LG has purchased infringing display products that are made, used, offered for sale, sold within, and/or imported into the United States, including this District by third party manufacturers, distributors, and/or importers.

COUNT I

Patent Infringement of U.S. Patent No. 7,434,974

25. Plaintiffs repeat and re-allege each and every allegation of paragraphs 1-23 as though fully set forth herein.

26. The '974 patent is valid and enforceable.

27. LG has never been licensed, either expressly or impliedly, under the '974 patent.

28. Upon information and belief, to the extent any marking or notice was required by 35 U.S.C. § 287, IDT has complied with the requirements of that statute by providing actual or constructive notice to LG of its alleged infringement. Upon information and belief, IDT surmises that any express licensees of the '974 patent have complied with the marking requirements of 35 U.S.C. § 287 by placing a notice of the '974 patent on all goods made, offered for sale, sold within, and/or imported into the United States that embody one or more claims of that patent.

29. Upon information and belief, LG has been and is directly infringing under 35 U.S.C. § 271(a), either literally or under the doctrine of equivalents, and/or indirectly infringing, by way of inducement with specific intent under 35 U.S.C. § 271(b), the ’974 patent by making, using, offering to sell, and/or selling to third-party distributors, and/or consumers (directly or through intermediaries and/or subsidiaries) in this District and elsewhere within the United States and/or importing into the United States, without authority, display products that include all of the limitations of one or more claims of the ’974 patent, including but not limited to mobile phones, tablets, televisions, and monitors with an LCD, their display components, and/or other products made, used, sold, offered for sale, or imported by LG that include all of the limitations of one or more claims of the ’974 patent.

30. Upon information and belief, distributors and consumers that purchase LG’s display products that include all of the limitations of one or more claims of the ’974 patent, including but not limited to mobile phones, tablets, televisions, and monitors with an LCD, also directly infringe, either literally or under the doctrine of equivalents, under 35 U.S.C. § 271(a), the ’974 patent by using, offering to sell, and/or selling to third-party distributors or consumers (directly or through intermediaries and/or subsidiaries) in this District and elsewhere within the United States and/or importing into the United States, those infringing display products.

31. Upon information and belief, the third-party manufacturers, distributors, and importers that sell display products to LG that include all of the limitations of one or more claims of the ’974 patent, also directly infringe, either literally or under the doctrine of equivalents, under 35 U.S.C. § 271(a), the ’974 patent by making, offering to sell, and/or selling (directly or through intermediaries and/or subsidiaries) infringing products in this District and elsewhere within the United States and/or importing infringing products into the United States.

32. Upon information and belief, LG had knowledge of the '974 patent and its infringing conduct at least since January 30, 2013, and likely as early as April 23, 2012, as described below.

33. [redacted]

34. [redacted]

35. [redacted].

36. [redacted]

37. On June 28, 2013, Plaintiff IDT filed lawsuits against several parties in the Eastern District of Texas, alleging infringement of the ’974 patent, including Dell Inc. (“Dell”) and Hewlett-Packard Co. (“HP”). *Innovative Display Technologies LLC v. Dell, Inc.*, Case No. 2:13-cv-00523-RSP (E.D. Tex.); *Innovative Display Technologies LLC v. Hewlett-Packard Company*, Case No. 2:13-cv-00524-JRG-RSP (E.D. Tex.). On December 20, 2013, Plaintiff IDT served

infringement contentions against Dell and HP for the '974 patent. Those contentions alleged infringement of the '974 patent based on some of the same display products that remain unlicensed and accused in this lawsuit (*e.g.*, LP133WH2-TLGA, LP156WH3-TLSA, LP156WH4-TLQ2). LG publicly admitted that it was indemnifying Dell and HP in those lawsuits. On March 10, 2015, the lawsuits against Dell and HP were dismissed following a settlement agreement between the parties.

[redacted]

38. For many other lawsuits filed in the Eastern District of Texas and in the District of Delaware, Plaintiffs believe that LG is or was indemnifying or obligated to indemnify the defendants for infringement of the patents-in-suit based on LG supplying those defendants with infringing display products. Those lawsuits include, but are not limited to, the following:

(a) *Innovative Display Technologies LLC v. Acer Inc. et al.*, Case No. 2:13-cv-00522-JRG-RSP (E.D. Tex., filed 06/28/2013)

(b) *Innovative Display Technologies LLC v. Huawei Investment and Holding Co., Ltd. et al.*, Case No. 2:13-cv-00525-JRG (E.D. Tex., filed 06/28/2013)

(c) *Innovative Display Technologies LLC v BlackBerry Limited et al.*, Case No. 2:13-cv-00526-JRG (E.D. Tex., filed 06/28/2013)

(d) *Innovative Display Technologies LLC v. ZTE Corporation et al., Case* No. 2:13-cv-00527-JRG (E.D. Tex., filed 06/28/2013)

(e) *Innovative Display Technologies LLC v. Nokia Corporation et al.*, Case No. 2:13-cv-00784-JRG (E.D. Tex., filed 10/01/2013)

(f) *Innovative Display Technologies LLC v. Apple Inc.*, Case No. 2:14-cv-00030-JRG (E.D. Tex., filed 01/17/2014)

(g) *Innovative Display Technologies LLC v. BMW of North America, LLC et al.*, Case No. 2:14-cv-00106-JRG (E.D. Tex., filed 02/21/2014)

(h) *Innovative Display Technologies LLC v. Toyota Motor Corporation et al.*, Case No. 2:14-cv-00200-JRG (E.D. Tex., filed 03/10/2014)

(i) *Innovative Display Technologies LLC v. Hyundai Motor Group et al.*, Case No. 2:14-cv-00201-JRG (E.D. Tex., filed 03/10/2014)

(j) *Innovative Display Technologies LLC v. Nissan Motor Co., Ltd. et al.*, Case No. 2:14-cv-00202-JRG (E.D. Tex., filed 03/10/2014)

(k) *Innovative Display Technologies LLC v. Volkswagen AG et al.*, Case No. 2:14-cv-00300-JRG (E.D. Tex., filed 04/07/2014)

(l) *Innovative Display Technologies LLC et al. v. Apple Inc.*, Case No. 2:14-cv-00301-JRG (E.D. Tex., filed 04/08/2014)

(m) *Innovative Display Technologies LLC v. Google Inc. et al.*, Case No. 2:14-cv-00302-JRG-RSP (E.D. Tex., filed 04/08/2014)

(n) *Innovative Display Technologies LLC v. Best Buy Co., Inc. et al.*, Case No. 2:14-cv-00532-JRG (E.D. Tex., filed 04/24/2014)

(o) *Innovative Display Technologies LLC v. Mercedes-Benz U.S. International, Inc. et al.*, Case No. 2:14-cv-00535-JRG (E.D. Tex., filed 04/24/2014)

(p) *Innovative Display Technologies LLC v. Mazda Motor Corporation et al.*, Case No. 2:14-cv-00624-JRG (E.D. Tex., filed 05/13/2014)

(q) *Delaware Display Group LLC et al. v. Amazon.com Inc.*, Case No. 1:13-cv-02106-RGA (D. Del., filed 12/31/2013)

(r) *Delaware Display Group LLC et al. v. HTC Corporation et al.*, Case No. 1:13-cv-02107-RGA (D. Del., filed 12/31/2013)

(s) *Delaware Display Group LLC et al. v. Lenovo Holding Company Inc. et al.*, Case No. 1:13-cv-02108-RGA (D. Del., filed 12/31/2013)

(t) *Delaware Display Group LLC et al. v. Sony Corporation et al.*, Case No. 1:13-cv-02111-RGA (D. Del. , filed 12/31/2013)

(u) *Innovative Display Technologies LLC v. Ford Motor Company*, Case No. 1:14-cv-00849-RGA (D. Del., filed 06/30/2014)

(v) *Innovative Display Technologies LLC v. General Motors* LLC, Case No. 1:14-cv-00850-RGA (D. Del. , filed 06/30/2014)

39. On December 31, 2013, Plaintiffs filed their original complaint against LG in this case, asserting infringement of the ’974 patent. In discovery in this case, LG has admitted that it had knowledge of the ’974 patent prior to the filing of that original complaint. Plaintiffs identified their initial list of accused LG products on August 22, 2014. Plaintiffs served LG with preliminary infringement contentions on November 21, 2014. Plaintiffs amended their list of accused display products against LG on March 30, 2015. On October 14, 2015, Plaintiffs served supplemental infringement contentions on LG.

40. On July 1, 2014, LG filed an *inter partes* review (“IPR”) petition with the Patent Trial and Appeal Board (“PTAB”) against the ’974 patent (IPR2014-01092). On January 13, 2015, the PTAB denied institution of that IPR. On March 9, 2015, the PTAB denied LG’s request for a rehearing on the decision to deny institution of that IPR. On December 29, 2014, LG filed another IPR petition (IPR2015-00497) against the ’974 patent. The PTAB denied institution of that petition

on July 15, 2015. None of LG's *inter partes* review petitions against the '974 patent has been instituted.

41. LG's acts of infringement of the '974 patent have been willful and intentional. Since at least the above-mentioned date of notice, LG has acted with an objectively high likelihood that its actions constituted infringement of the '974 patent by refusing to take a license and continuing to make, sell, and import display products that include all of the limitations of one or more claims of the '974 patent, and the objectively-defined risk of infringement was either known or so obvious that it should have been known. LG has known about the '974 patent since as least as early as January 30, 2013. LG has been aware that it infringes the '974 patent since at least then; LG has participated in many lawsuits involving the '974 patent since then. LG has failed in its several attempts to have the '974 patent invalidated by *inter partes* review. Instead of taking a license during that time, LG has opted to make the business decision to "efficiently infringe" the '974 patent. In doing so, LG has willfully infringed the patents-in-suit.

42. Upon information and belief, since at least the above-mentioned date when IDT formally placed LG on notice of its infringement , LG has actively induced, under U.S.C. § 271(b), third-party manufacturers, distributors, importers and/or consumers that purchase or sell display products that include all of the limitations of one or more claims of the '974 patent, including but not limited to mobile phones, tablets, televisions, and monitors with an LCD, to directly infringe one or more claims of the '974 patent. Since at least the notice provided on the above-mentioned date, LG does so with knowledge, or with willful blindness of the fact, that the induced acts constitute infringement of the '974 patent. Upon information and belief, LG intends to cause, and has taken affirmative steps to induce, infringement by these third-party manufacturers, distributors, importers, and/or consumers by, *inter alia*, creating advertisements that promote the infringing use

of display products, creating established distribution channels for these products into and within the United States, purchasing these products, manufacturing these products in conformity with U.S. laws and regulations, distributing or making available instructions or manuals for these products to purchasers and prospective buyers, and/or providing technical support, replacement parts, or services for these products to these purchasers in the United States.

43. As a direct and proximate result of these acts of patent infringement, LG has encroached on the exclusive rights of IDT and its licensees to practice the ’974 patent, for which IDT is entitled to at least a reasonable royalty.

COUNT II

Patent Infringement of U.S. Patent No. 7,537,370

44. Plaintiffs repeat and re-allege each and every allegation of paragraphs 1-43 as though fully set forth herein.

45. The ’370 patent is valid and enforceable.

46. LG has never been licensed, either expressly or impliedly, under the ’370 patent.

47. Upon information and belief, to the extent any marking or notice was required by 35 U.S.C. § 287, IDT has complied with the requirements of that statute by providing actual or constructive notice to LG of its alleged infringement. Upon information and belief, IDT surmises that any express licensees of the ’370 patent have complied with the marking requirements of 35 U.S.C. § 287 by placing a notice of the ’370 patent on all goods made, offered for sale, sold within, and/or imported into the United States that embody one or more claims of that patent.

48. Upon information and belief, LG has been and is directly infringing under 35 U.S.C. § 271(a), either literally or under the doctrine of equivalents, and/or indirectly infringing, by way of inducement with specific intent under 35 U.S.C. § 271(b), the ’370 patent by making, using, offering to sell, and/or selling to third-party distributors, and/or consumers (directly or

through intermediaries and/or subsidiaries) in this District and elsewhere within the United States and/or importing into the United States, without authority, display products that include all of the limitations of one or more claims of the ’370 patent, including but not limited to mobile phones, tablets, televisions, and monitors with an LCD, their display components, and/or other products made, used, sold, offered for sale, or imported by LG that include all of the limitations of one or more claims of the’370 patent.

49. Upon information and belief, distributors and consumers that purchase LG’s display products that include all of the limitations of one or more claims of the ’370 patent, including but not limited to mobile phones, tablets, televisions, and monitors with an LCD, also directly infringe, either literally or under the doctrine of equivalents, under 35 U.S.C. § 271(a), the ’370 patent by using, offering to sell, and/or selling to third-party distributors or consumers (directly or through intermediaries and/or subsidiaries) in this District and elsewhere within the United States and/or importing into the United States, those infringing display products.

50. Upon information and belief, the third-party manufacturers, distributors, and importers that sell display products to LG that include all of the limitations of one or more claims of the ’370 patent, also directly infringe, either literally or under the doctrine of equivalents, under 35 U.S.C. § 271(a), the ’370 patent by making, offering to sell, and/or selling (directly or through intermediaries and/or subsidiaries) infringing products in this District and elsewhere within the United States and/or importing infringing products into the United States.

51. Upon information and belief, LG had knowledge of the ’370 patent and its infringing conduct at least since January 30, 2013, and likely as early as April 23, 2012, as described below.

52. [redacted]

53. [redacted]

54. [redacted]

[redacted]

55. [redacted]

56. On June 28, 2013, Plaintiff IDT filed lawsuits against several parties in the Eastern District of Texas, alleging infringement of the ’370 patent, including Dell and HP. *Innovative Display Technologies LLC v. Dell, Inc.*, Case No. 2:13-cv-00523-RSP (E.D. Tex.); *Innovative Display Technologies LLC v. Hewlett-Packard Company*, Case No. 2:13-cv-00524-JRG-RSP (E.D. Tex.). On December 20, 2013, Plaintiff IDT served infringement contentions against Dell and HP for the ’370 patent. Those contentions alleged infringement of the ’370 patent based on some of the same display products that remain unlicensed and accused in this lawsuit (*e.g.*, LP156WH3-TLSA, LP156WH4-TLQ2). LG publicly admitted that it was indemnifying Dell and HP in those lawsuits. On March 10, 2015, the lawsuits against Dell and HP were dismissed

following a settlement agreement between the parties. [redacted]

57. For many other lawsuits filed in the Eastern District of Texas and in the District of Delaware, Plaintiffs believe that LG is or was indemnifying or obligated to indemnify the defendants for infringement of the patents-in-suit based on LG supplying those defendants with infringing display products. Those lawsuits include, but are not limited to, the following:

(a) *Innovative Display Technologies LLC v. Acer Inc. et al.*, Case No. 2:13-cv-00522-JRG-RSP (E.D. Tex., filed 06/28/2013)

(b) *Innovative Display Technologies LLC v. Huawei Investment and Holding Co., Ltd. et al.*, Case No. 2:13-cv-00525-JRG (E.D. Tex., filed 06/28/2013)

(c) *Innovative Display Technologies LLC v BlackBerry Limited et al.*, Case No. 2:13-cv-00526-JRG (E.D. Tex., filed 06/28/2013)

(d) *Innovative Display Technologies LLC v. ZTE Corporation et al., Case* No. 2:13-cv-00527-JRG (E.D. Tex., filed 06/28/2013)

(e) *Innovative Display Technologies LLC v. Nokia Corporation et al.*, Case No. 2:13-cv-00784-JRG (E.D. Tex., filed 10/01/2013)

(f) *Innovative Display Technologies LLC v. Apple Inc.*, Case No. 2:14-cv-00030-JRG (E.D. Tex., filed 01/17/2014)

(g) *Innovative Display Technologies LLC v. BMW of North America, LLC et al.*, Case No. 2:14-cv-00106-JRG (E.D. Tex., filed 02/21/2014)

(h) *Innovative Display Technologies LLC v. Toyota Motor Corporation et al.*, Case No. 2:14-cv-00200-JRG (E.D. Tex., filed 03/10/2014)

(i) *Innovative Display Technologies LLC v. Hyundai Motor Group et al.*, Case No. 2:14-cv-00201-JRG (E.D. Tex., filed 03/10/2014)

(j) *Innovative Display Technologies LLC v. Nissan Motor Co., Ltd. et al.*, Case No. 2:14-cv-00202-JRG (E.D. Tex., filed 03/10/2014)

(k) *Innovative Display Technologies LLC v. Volkswagen AG et al.*, Case No. 2:14-cv-00300-JRG (E.D. Tex., filed 04/07/2014)

(l) *Innovative Display Technologies LLC et al. v. Apple Inc.*, Case No. 2:14-cv-00301-JRG (E.D. Tex., filed 04/08/2014)

(m) *Innovative Display Technologies LLC v. Google Inc. et al.*, Case No. 2:14-cv-00302-JRG-RSP (E.D. Tex., filed 04/08/2014)

(n) *Innovative Display Technologies LLC v. Best Buy Co., Inc. et al.*, Case No. 2:14-cv-00532-JRG (E.D. Tex., filed 04/24/2014)

(o) *Innovative Display Technologies LLC v. Mercedes-Benz U.S. International, Inc. et al.*, Case No. 2:14-cv-00535-JRG (E.D. Tex., filed 04/24/2014)

(p) *Innovative Display Technologies LLC v. Mazda Motor Corporation et al.*, Case No. 2:14-cv-00624-JRG (E.D. Tex., filed 05/13/2014)

(q) *Delaware Display Group LLC et al. v. Amazon.com Inc.*, Case No. 1:13-cv-02106-RGA (D. Del., filed 12/31/2013)

(r) *Delaware Display Group LLC et al. v. HTC Corporation et al.*, Case No. 1:13-cv-02107-RGA (D. Del., filed 12/31/2013)

(s) *Delaware Display Group LLC et al. v. Lenovo Holding Company Inc. et al.*, Case No. 1:13-cv-02108-RGA (D. Del., filed 12/31/2013)

(t) *Delaware Display Group LLC et al. v. Sony Corporation et al.*, Case No. 1:13-cv-02111-RGA (D. Del. , filed 12/31/2013)

(u) *Innovative Display Technologies LLC v. Ford Motor Company*, Case No. 1:14-cv-00849-RGA (D. Del., filed 06/30/2014)

(v) *Innovative Display Technologies LLC v. General Motors* LLC, Case No. 1:14-cv-00850-RGA (D. Del. , filed 06/30/2014).

58. On December 31, 2013, Plaintiffs filed their original complaint against LG in this case, asserting infringement of the ’370 patent. In discovery in this case, LG has admitted that it had knowledge of the ’370 patent prior to the filing of that original complaint. Plaintiffs identified their initial list of accused LG products on August 22, 2014. Plaintiffs served LG with preliminary infringement contentions on November 21, 2014. Plaintiffs amended their list of accused display products against LG on March 30, 2015. On October 14, 2015, Plaintiffs served supplemental infringement contentions on LG.

59. On July 1, 2014, LG filed an IPR petition with the PTAB against the ’370 patent (IPR2014-01096). On January 13, 2015, the PTAB instituted that IPR for only claims 15 and 27 – neither of which are asserted in this case. The PTAB declined to institute IPR2014-01096 against the ’370 patent for any of the claims asserted in this case. On March 9, 2015, the PTAB denied LG’s request for a rehearing on the decision to deny institution of that IPR for the asserted claims in this case. On December 29, 2014, LG filed another IPR petition (IPR2015-00493) against the ’370 patent. The result was the same as for IPR2014-01096 – none of the asserted claims in this case was instituted. Thus, for the asserted claims in this lawsuit, none of LG’s *inter partes* review petitions against the ’370 patent has been instituted.

60. LG's acts of infringement of the '370 patent have been willful and intentional. Since at least the above-mentioned date of notice, LG has acted with an objectively high likelihood that its actions constituted infringement of the '370 patent by refusing to take a license and continuing to make, sell, and import display products that include all of the limitations of one or more claims of the '370 patent, and the objectively-defined risk of infringement was either known or so obvious that it should have been known. LG has known about the '370 patent since as least as early as January 30, 2013. LG has been aware that it infringes the '370 patent since at least then; LG has participated in many lawsuits involving the '370 patent since then. LG has failed in its several attempts to have the asserted claims of the '370 patent invalidated by *inter partes* review. Instead of taking a license during that time, LG has opted to make the business decision to "efficiently infringe" the '370 patent. In doing so, LG has willfully infringed the patents-in-suit.

61. Upon information and belief, since at least the above-mentioned date when IDT formally placed LG on notice of its infringement, LG has actively induced, under U.S.C. § 271(b), third-party manufacturers, distributors, importers and/or consumers that purchase or sell display products that include all of the limitations of one or more claims of the '370 patent, including but not limited to mobile phones, tablets, televisions, and monitors with an LCD, to directly infringe one or more claims of the '370 patent. Since at least the notice provided on the above-mentioned date, LG does so with knowledge, or with willful blindness of the fact, that the induced acts constitute infringement of the '370 patent. Upon information and belief, LG intends to cause, and has taken affirmative steps to induce, infringement by these third-party manufacturers, distributors, importers, and/or consumers by, *inter alia*, creating advertisements that promote the infringing use of display products, creating established distribution channels for these products into and within the United States, purchasing these products, manufacturing these products in conformity with

U.S. laws and regulations, distributing or making available instructions or manuals for these products to purchasers and prospective buyers, and/or providing technical support, replacement parts, or services for these products to these purchasers in the United States.

62. As a direct and proximate result of these acts of patent infringement, LG has encroached on the exclusive rights of IDT and its licensees to practice the ’370 patent, for which IDT is entitled to at least a reasonable royalty.

COUNT III

Patent Infringement of U.S. Patent No. 7,914,196

63. Plaintiffs repeat and re-allege each and every allegation of paragraphs 1-62 as though fully set forth herein.

64. The ’196 patent is valid and enforceable.

65. LG has never been licensed, either expressly or impliedly, under the ’196 patent.

66. Upon information and belief, to the extent any marking or notice was required by 35 U.S.C. § 287, DDG has complied with the requirements of that statute by providing actual or constructive notice to LG of its alleged infringement. Upon information and belief, DDG surmises that any express licensees of the ’196 patent have complied with the marking requirements of 35 U.S.C. § 287 by placing a notice of the ’196 patent on all goods made, offered for sale, sold within, and/or imported into the United States that embody one or more claims of that patent.

67. Upon information and belief, LG has been and is directly infringing under 35 U.S.C. § 271(a), either literally or under the doctrine of equivalents, and/or indirectly infringing, by way of inducement with specific intent under 35 U.S.C. § 271(b), the ’196 patent by making, using, offering to sell, and/or selling to third-party distributors, and/or consumers (directly or through intermediaries and/or subsidiaries) in this District and elsewhere within the United States and/or importing into the United States, without authority, display products that include all of the

limitations of one or more claims of the ’196 patent, including but not limited to mobile phones, tablets, televisions, and monitors with an LCD, their display components, and/or other products made, used, sold, offered for sale, or imported by LG that include all of the limitations of one or more claims of the ’196 patent.

68. Upon information and belief, distributors and consumers that purchase LG’s display products that include all of the limitations of one or more claims of the ’196 patent, including but not limited to mobile phones, tablets, televisions, and monitors with an LCD, also directly infringe, either literally or under the doctrine of equivalents, under 35 U.S.C. § 271(a), the ’196 patent by using, offering to sell, and/or selling to third-party distributors or consumers (directly or through intermediaries and/or subsidiaries) in this District and elsewhere within the United States and/or importing into the United States, those infringing display products.

69. Upon information and belief, the third-party manufacturers, distributors, and importers that sell display products to LG that include all of the limitations of one or more claims of the ’196 patent, also directly infringe, either literally or under the doctrine of equivalents, under 35 U.S.C. § 271(a), the ’196 patent by making, offering to sell, and/or selling (directly or through intermediaries and/or subsidiaries) infringing products in this District and elsewhere within the United States and/or importing infringing products into the United States.

70. Upon information and belief, LG had knowledge of the ’196 patent and its infringing conduct at least since January 30, 2013, and likely as early as April 23, 2012, as described below.

71. [redacted]

72.

73.

74. [redacted]

75. On December 31, 2013, Plaintiffs filed their original complaint against LG in this case, asserting infringement of the ’196 patent. Plaintiffs identified their initial list of accused LG products on August 22, 2014. Plaintiffs served LG with preliminary infringement contentions on November 21, 2014. Plaintiffs amended their list of accused display products against LG on March 30, 2015. On October 14, 2015, Plaintiffs served supplemental infringement contentions on LG.

76. On August 21, 2014, LG filed an IPR petition with the PTAB against the ’196 patent (IPR2014-01359). On March 2, 2015, the PTAB declined to institute IPR2014-01359 against the ’196 patent. On December 29, 2014, LG filed another IPR petition (IPR2015-00492) against the ’196 patent. The PTAB declined to institute IPR2015-00492 against the ’196 patent. Thus, none of LG’s *inter partes* review petitions against the ’196 patent has been instituted.

77. LG’s acts of infringement of the ’196 patent have been willful and intentional. Since at least the above-mentioned date of notice, LG has acted with an objectively high likelihood

that its actions constituted infringement of the ’196 patent by refusing to take a license and continuing to make, sell, and import display products that include all of the limitations of one or more claims of the ’196 patent, and the objectively-defined risk of infringement was either known or so obvious that it should have been known. LG has known about the ’196 patent since as least as early as January 30, 2013. LG has been aware that it infringes the ’196 patent since at least then. LG has failed in its several attempts to have the asserted claims of the ’196 patent invalidated by *inter partes* review. Instead of taking a license during that time, LG has opted to make the business decision to “efficiently infringe” the ’196 patent. In doing so, LG has willfully infringed the patents-in-suit.

78. Upon information and belief, since at least the above-mentioned date when DDG formally placed LG on notice of its infringement, LG has actively induced, under U.S.C. § 271(b), third-party manufacturers, distributors, importers and/or consumers that purchase or sell display products that include all of the limitations of one or more claims of the ’196 patent, including but not limited to mobile phones, tablets, televisions, and monitors with an LCD, to directly infringe one or more claims of the ’196 patent. Since at least the notice provided on the above-mentioned date, LG does so with knowledge, or with willful blindness of the fact, that the induced acts constitute infringement of the ’196 patent. Upon information and belief, LG intends to cause, and has taken affirmative steps to induce, infringement by these third-party manufacturers, distributors, importers, and/or consumers by, *inter alia*, creating advertisements that promote the infringing use of display products, creating established distribution channels for these products into and within the United States, purchasing these products, manufacturing these products in conformity with U.S. laws and regulations, distributing or making available instructions or manuals for these

products to purchasers and prospective buyers, and/or providing technical support, replacement parts, or services for these products to these purchasers in the United States.

79. As a direct and proximate result of these acts of patent infringement, LG has encroached on the exclusive rights of DDG and its licensees to practice the ’196 patent, for which DDG is entitled to at least a reasonable royalty.

COUNT IV

Patent Infringement of U.S. Patent No. 8,215,816

80. Plaintiffs repeat and re-allege each and every allegation of paragraphs 1-79 as though fully set forth herein.

81. The ’816 patent is valid and enforceable.

82. LG has never been licensed, either expressly or impliedly, under the ’816 patent.

83. Upon information and belief, to the extent any marking or notice was required by 35 U.S.C. § 287, IDT has complied with the requirements of that statute by providing actual or constructive notice to LG of its alleged infringement. Upon information and belief, IDT surmises that any express licensees of the ’816 patent have complied with the marking requirements of 35 U.S.C. § 287 by placing a notice of the ’816 patent on all goods made, offered for sale, sold within, and/or imported into the United States that embody one or more claims of that patent.

84. Upon information and belief, LG has been and is directly infringing under 35 U.S.C. § 271(a), either literally or under the doctrine of equivalents, and/or indirectly infringing, by way of inducement with specific intent under 35 U.S.C. § 271(b), the ’816 patent by making, using, offering to sell, and/or selling to third-party distributors, and/or consumers (directly or through intermediaries and/or subsidiaries) in this District and elsewhere within the United States and/or importing into the United States, without authority, display products that include all of the

limitations of one or more claims of the ’816 patent, including but not limited to mobile phones, tablets, televisions, and monitors with an LCD, their display components, and/or other products made, used, sold, offered for sale, or imported by LG that include all of the limitations of one or more claims of the ’816 patent.

85. Upon information and belief, distributors and consumers that purchase LG’s display products that include all of the limitations of one or more claims of the ’816 patent, including but not limited to mobile phones, tablets, televisions, and monitors with an LCD, also directly infringe, either literally or under the doctrine of equivalents, under 35 U.S.C. § 271(a), the ’816 patent by using, offering to sell, and/or selling to third-party distributors or consumers (directly or through intermediaries and/or subsidiaries) in this District and elsewhere within the United States and/or importing into the United States, those infringing display products.

86. Upon information and belief, the third-party manufacturers, distributors, and importers that sell display products to LG that include all of the limitations of one or more claims of the ’816 patent, also directly infringe, either literally or under the doctrine of equivalents, under 35 U.S.C. § 271(a), the ’816 patent by making, offering to sell, and/or selling (directly or through intermediaries and/or subsidiaries) infringing products in this District and elsewhere within the United States and/or importing infringing products into the United States.

87. Upon information and belief, LG had knowledge of the ’816 patent and its infringing conduct at least since February 8, 2013, and likely as early as the issuance of the ’816 patent, as described below.

88. [redacted]

[redacted]

89. [redacted]

90. [redacted]

[redacted]

91. On June 28, 2013, Plaintiff IDT filed lawsuits against several parties in the Eastern District of Texas, alleging infringement of the '816 patent, including Dell and HP. *Innovative Display Technologies LLC v. Dell, Inc.*, Case No. 2:13-cv-00523-RSP (E.D. Tex.); *Innovative Display Technologies LLC v. Hewlett-Packard Company*, Case No. 2:13-cv-00524-JRG-RSP (E.D. Tex.). On December 20, 2013, Plaintiff IDT served infringement contentions against Dell and HP for the '816 patent. Those contentions alleged infringement of the '816 patent based on some of the same display products that remain unlicensed and accused in this lawsuit (*e.g.*, LP133WH2-TLGA, LP156WH3-TLSA, LP156WH4-TLQ2). LG publicly admitted that it was indemnifying Dell and HP in those lawsuits. On March 10, 2015, the lawsuits against Dell and HP were dismissed following a settlement agreement between the parties. [redacted]

92. For many other lawsuits filed in the Eastern District of Texas and in the District of Delaware, Plaintiffs believe that LG is or was indemnifying or obligated to indemnify the defendants for infringement of the patents-in-suit based on LG supplying those defendants with infringing display products. Those lawsuits include, but are not limited to, the following:

(a) *Innovative Display Technologies LLC v. Acer Inc. et al.*, Case No. 2:13-cv-00522-JRG-RSP (E.D. Tex., filed 06/28/2013)

(b) *Innovative Display Technologies LLC v. Huawei Investment and Holding Co., Ltd. et al.*, Case No. 2:13-cv-00525-JRG (E.D. Tex., filed 06/28/2013)

(c) *Innovative Display Technologies LLC v BlackBerry Limited et al.*, Case No. 2:13-cv-00526-JRG (E.D. Tex., filed 06/28/2013)

(d) *Innovative Display Technologies LLC v. ZTE Corporation et al., Case* No. 2:13-cv-00527-JRG (E.D. Tex., filed 06/28/2013)

(e) *Innovative Display Technologies LLC v. Nokia Corporation et al.*, Case No. 2:13-cv-00784-JRG (E.D. Tex., filed 10/01/2013)

(f) *Innovative Display Technologies LLC v. Apple Inc.*, Case No. 2:14-cv-00030-JRG (E.D. Tex., filed 01/17/2014)

(g) *Innovative Display Technologies LLC v. BMW of North America, LLC et al.*, Case No. 2:14-cv-00106-JRG (E.D. Tex., filed 02/21/2014)

(h) *Innovative Display Technologies LLC v. Toyota Motor Corporation et al.*, Case No. 2:14-cv-00200-JRG (E.D. Tex., filed 03/10/2014)

(i) *Innovative Display Technologies LLC v. Hyundai Motor Group et al.*, Case No. 2:14-cv-00201-JRG (E.D. Tex., filed 03/10/2014)

(j) *Innovative Display Technologies LLC v. Nissan Motor Co., Ltd. et al.*, Case No. 2:14-cv-00202-JRG (E.D. Tex., filed 03/10/2014)

(k) *Innovative Display Technologies LLC v. Volkswagen AG et al.*, Case No. 2:14-cv-00300-JRG (E.D. Tex., filed 04/07/2014)

(l) *Innovative Display Technologies LLC et al. v. Apple Inc.*, Case No. 2:14-cv-00301-JRG (E.D. Tex., filed 04/08/2014)

(m) *Innovative Display Technologies LLC v. Google Inc. et al.*, Case No. 2:14-cv-00302-JRG-RSP (E.D. Tex., filed 04/08/2014)

(n) *Innovative Display Technologies LLC v. Best Buy Co., Inc. et al.*, Case No. 2:14-cv-00532-JRG (E.D. Tex., filed 04/24/2014)

(o) *Innovative Display Technologies LLC v. Mercedes-Benz U.S. International, Inc. et al.*, Case No. 2:14-cv-00535-JRG (E.D. Tex., filed 04/24/2014)

(p) *Innovative Display Technologies LLC v. Mazda Motor Corporation et al.*, Case No. 2:14-cv-00624-JRG (E.D. Tex., filed 05/13/2014)

(q) *Delaware Display Group LLC et al. v. Amazon.com Inc.*, Case No. 1:13-cv-02106-RGA (D. Del., filed 12/31/2013)

(r) *Delaware Display Group LLC et al. v. HTC Corporation et al.*, Case No. 1:13-cv-02107-RGA (D. Del., filed 12/31/2013)

(s) *Delaware Display Group LLC et al. v. Lenovo Holding Company Inc. et al.*, Case No. 1:13-cv-02108-RGA (D. Del., filed 12/31/2013)

(t) *Delaware Display Group LLC et al. v. Sony Corporation et al.*, Case No. 1:13-cv-02111-RGA (D. Del. , filed 12/31/2013)

(u) *Innovative Display Technologies LLC v. Ford Motor Company*, Case No. 1:14-cv-00849-RGA (D. Del., filed 06/30/2014)

(v) *Innovative Display Technologies LLC v. General Motors* LLC, Case No. 1:14-cv-00850-RGA (D. Del. , filed 06/30/2014).

93. On December 31, 2013, Plaintiffs filed their original complaint against LG in this case, asserting infringement of the ’816 patent. Plaintiffs identified their initial list of accused LG products on August 22, 2014. Plaintiffs served LG with preliminary infringement contentions on November 21, 2014. Plaintiffs amended their list of accused display products against LG on March 30, 2015. On October 14, 2015, Plaintiffs served supplemental infringement contentions on LG.

94. On July 1, 2014, LG filed an IPR petition with the PTAB against the ’816 patent (IPR2014-01095). On January 13, 2015, the PTAB denied institution of that IPR. On December

29, 2014, LG filed another IPR petition (IPR2015-00496) against the '816 patent. The PTAB denied institution of that petition on July 20, 2015. None of LG's *inter partes* review petitions against the '816 patent has been instituted.

95. LG's acts of infringement of the '816 patent have been willful and intentional. Since at least the above-mentioned date of notice, LG has acted with an objectively high likelihood that its actions constituted infringement of the '816 patent by refusing to take a license and continuing to make, sell, and import display products that include all of the limitations of one or more claims of the '816 patent, and the objectively-defined risk of infringement was either known or so obvious that it should have been known. LG has known about the '816 patent since as least as early as February 8, 2013. LG has been aware that it infringes the '816 patent since at least then; LG has participated in many lawsuits involving the '816 patent since then. LG has failed in its several attempts to have the asserted claims of the '816 patent invalidated by *inter partes* review. Instead of taking a license during that time, LG has opted to make the business decision to "efficiently infringe" the '816 patent. In doing so, LG has willfully infringed the patents-in-suit.

96. Upon information and belief, since at least the above-mentioned date when IDT formally placed LG on notice of its infringement, LG has actively induced, under U.S.C. § 271(b), third-party manufacturers, distributors, importers and/or consumers that purchase or sell display products that include all of the limitations of one or more claims of the '816 patent, including but not limited to mobile phones, tablets, televisions, and monitors with an LCD, to directly infringe one or more claims of the '816 patent. Since at least the notice provided on the above-mentioned date, LG does so with knowledge, or with willful blindness of the fact, that the induced acts constitute infringement of the '816 patent. Upon information and belief, LG intends to cause, and has taken affirmative steps to induce, infringement by these third-party manufacturers, distributors,

importers, and/or consumers by, *inter alia*, creating advertisements that promote the infringing use of display products, creating established distribution channels for these products into and within the United States, purchasing these products, manufacturing these products in conformity with U.S. laws and regulations, distributing or making available instructions or manuals for these products to purchasers and prospective buyers, and/or providing technical support, replacement parts, or services for these products to these purchasers in the United States.

97. As a direct and proximate result of these acts of patent infringement, LG has encroached on the exclusive rights of IDT and its licensees to practice the ’816 patent, for which IDT is entitled to at least a reasonable royalty.

CONCLUSION

98. Plaintiffs are entitled to recover from LG the damages sustained by Plaintiffs as a result of LG’s wrongful acts in an amount subject to proof at trial, which, by law, cannot be less than a reasonable royalty, together with interest and costs as fixed by this Court.

99. Plaintiffs have incurred and will incur attorneys’ fees, costs, and expenses in the prosecution of this action. The circumstances of this dispute create an exceptional case within the meaning of 35 U.S.C. § 285, and Plaintiffs are entitled to recover their reasonable and necessary attorneys’ fees, costs, and expenses.

JURY DEMAND

100. Plaintiffs hereby request a trial by jury pursuant to Rule 38 of the Federal Rules of Civil Procedure.

PRAYER FOR RELIEF

101. Plaintiffs respectfully request that the Court find in its favor and against LG, and that the Court grant Plaintiffs the following relief:

A. A judgment that LG has infringed the patents-in-suit as alleged herein, directly and/or indirectly by way of inducing infringement of such patents;

B. A judgment for an accounting of all damages sustained by Plaintiffs as a result of the acts of infringement by LG;

C. A judgment and order requiring LG to pay Plaintiffs damages under 35 U.S.C. § 284, including up to treble damages for willful infringement as provided by 35 U.S.C. § 284, and any royalties determined to be appropriate;

D. A permanent injunction enjoining LG and its officers, directors, agents, servants, employees, affiliates, divisions, branches, subsidiaries, parents and all others acting in concert or privity with them from direct and/or indirect infringement of the patents-in-suit pursuant to 35 U.S.C. § 283;

E. A judgment and order requiring LG to pay Plaintiffs pre-judgment and post-judgment interest on the damages awarded;

F. A judgment and order finding this to be an exceptional case and requiring LG to pay the costs of this action (including all disbursements) and attorneys' fees as provided by 35 U.S.C. § 285; and

G. Such other and further relief as the Court deems just and equitable.

Dated: December 4, 2015

Respectfully submitted,

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EXHIBIT A

US007434974B2

(12) **United States Patent**
Parker

(10) **Patent No.: US 7,434,974 B2**
(45) **Date of Patent: Oct. 14, 2008**

(54) **LIGHT EMITTING PANEL ASSEMBLIES**

(75) Inventor: **Jeffery R. Parker**, Richfield, OH (US)

(73) Assignee: **Solid State Opto Limited** (VG)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 103 days.

(21) Appl. No.: **11/378,080**

(22) Filed: **Mar. 17, 2006**

(65) **Prior Publication Data**

US 2006/0158906 A1 Jul. 20, 2006

Related U.S. Application Data

(60) Continuation of application No. 10/784,527, filed on Feb. 23, 2004, now Pat. No. 7,160,015, which is a division of application No. 09/256,275, filed on Feb. 23, 1999, now Pat. No. 6,712,481, which is a continuation-in-part of application No. 08/778,089, filed on Jan. 2, 1997, now Pat. No. 6,079,838, which is a division of application No. 08/495,176, filed on Jun. 27, 1995, now Pat. No. 5,613,751.

(51) **Int. Cl.**
F21V 7/04 (2006.01)

(52) **U.S. Cl.** **362/612**; 362/619; 362/632; 362/634

(58) **Field of Classification Search** 362/231, 362/800, 27, 619, 613, 612, 620, 608, 609, 362/621, 600, 632, 634, 26
See application file for complete search history.

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(Continued)

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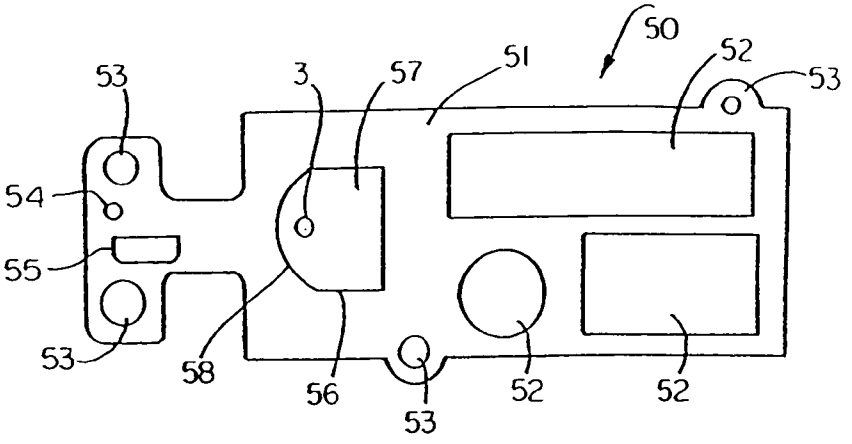
(74) *Attorney, Agent, or Firm*—Renner, Otto, Boisselle & Sklar, LLP

(57) **ABSTRACT**

Light emitting panel assembly includes a light emitting panel member received in a cavity or recess in a tray or housing. The panel member has a pattern of light extracting deformities on or in at least one surface of the panel member to cause light received from at least one LED light source positioned near or against the light entrance surface of the panel member to be emitted from a light emitting surface of the panel member. The tray or housing acts as an end edge and/or side edge reflector for the panel member to reflect light that would otherwise exit the panel member through the end edge and/or side edge back into the panel member for causing additional light to be emitted from the panel member.

24 Claims, 4 Drawing Sheets



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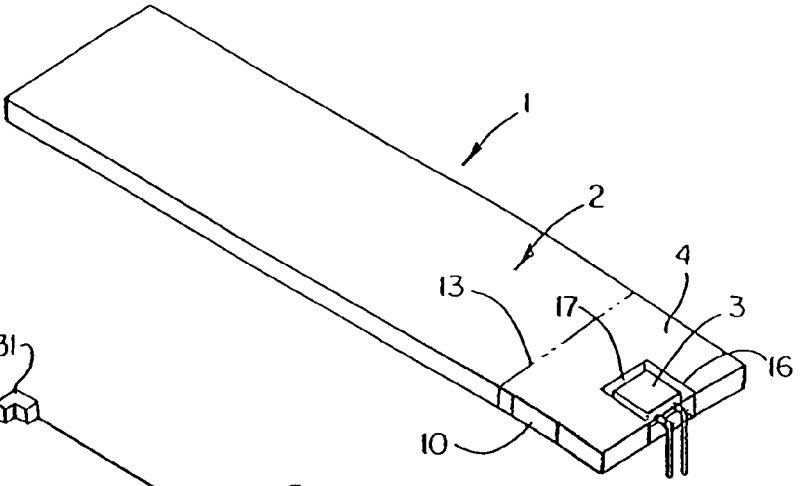

FIG. 1

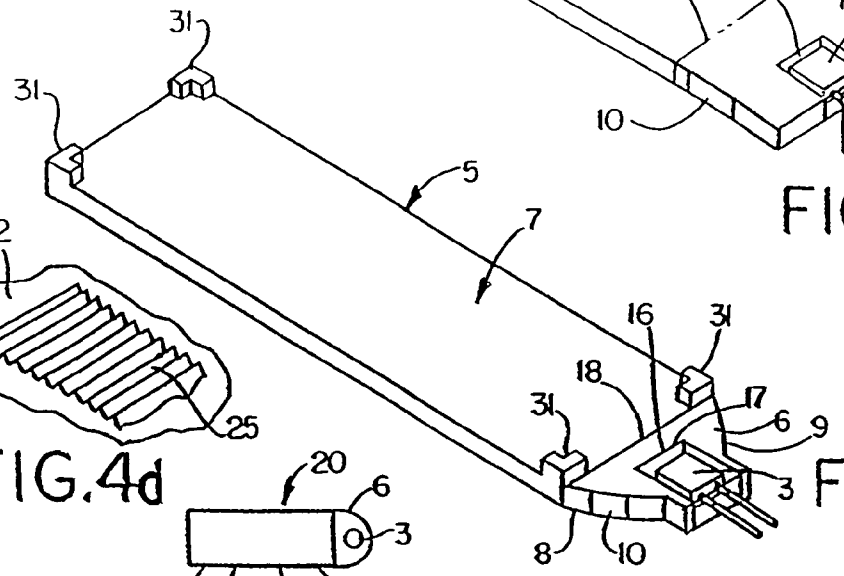

FIG. 2

FIG.4d

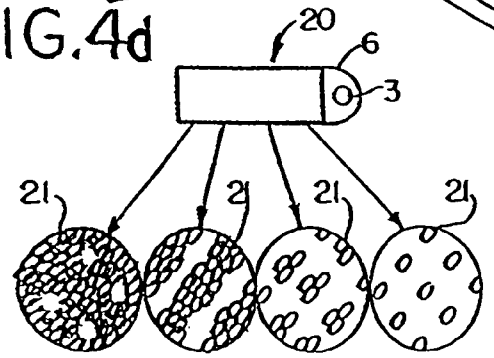

FIG.4a

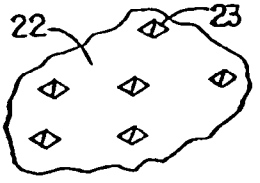

FIG.4b

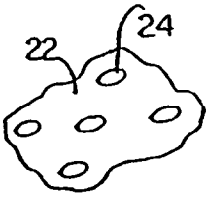

FIG.4c

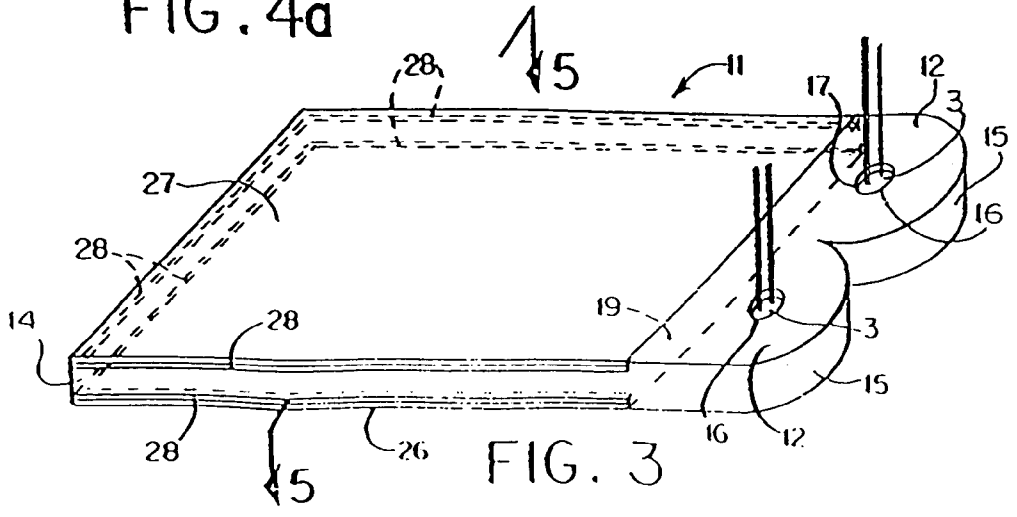

FIG. 3

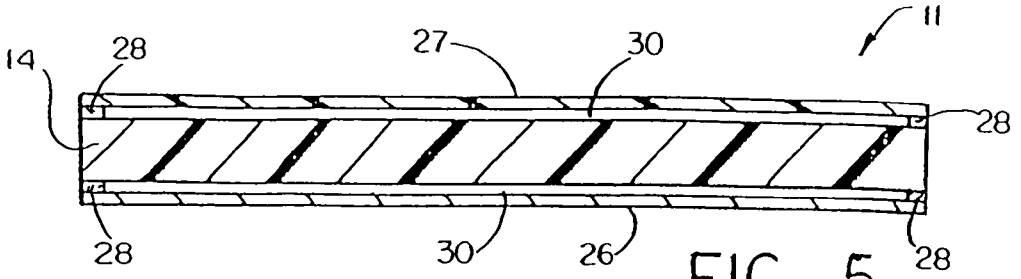

FIG. 5

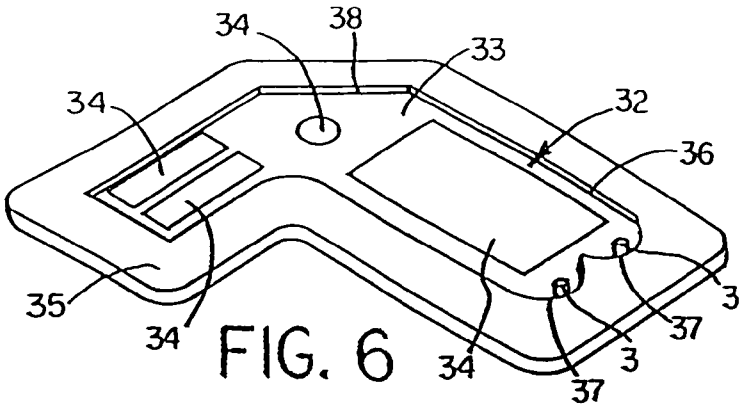

FIG. 6

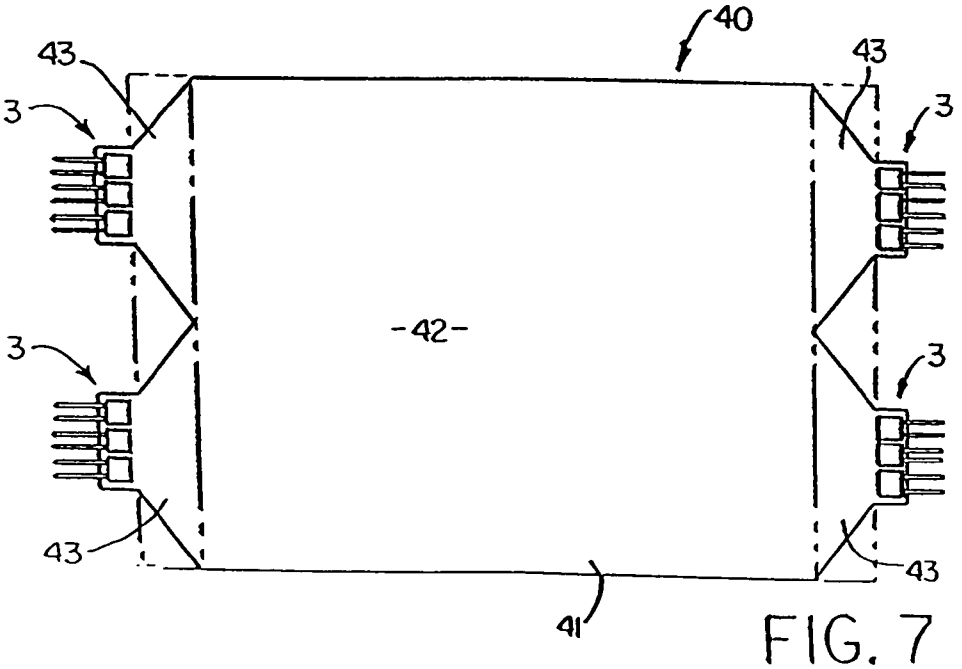

FIG. 7

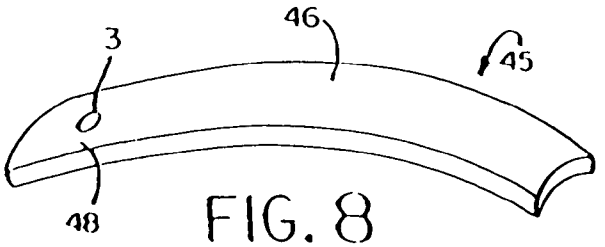

FIG. 8

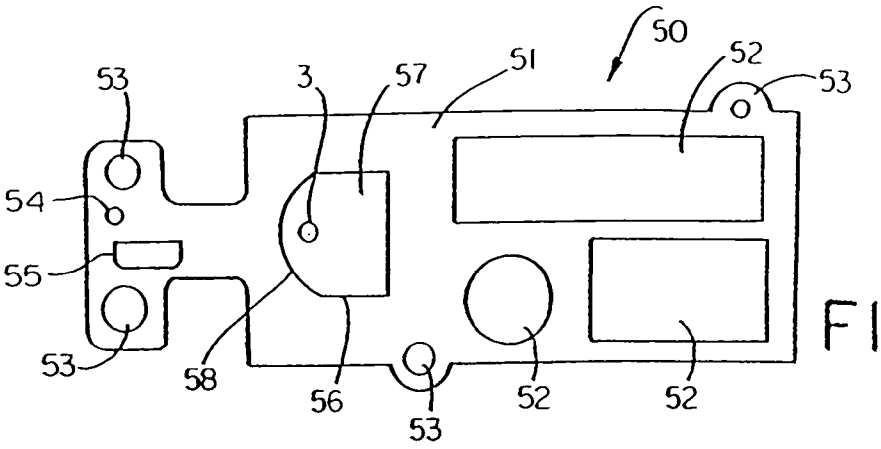

FIG. 9

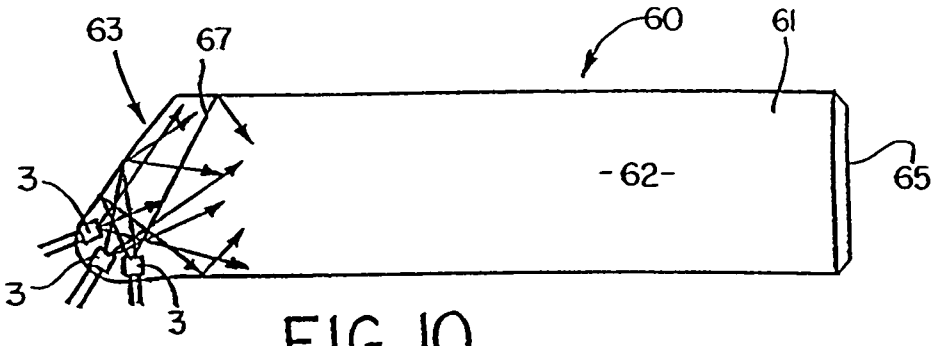

FIG. 10

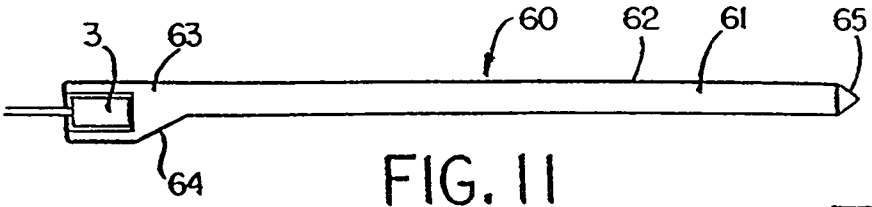

FIG. 11

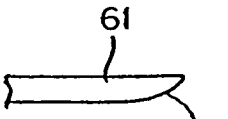

FIG. 11a

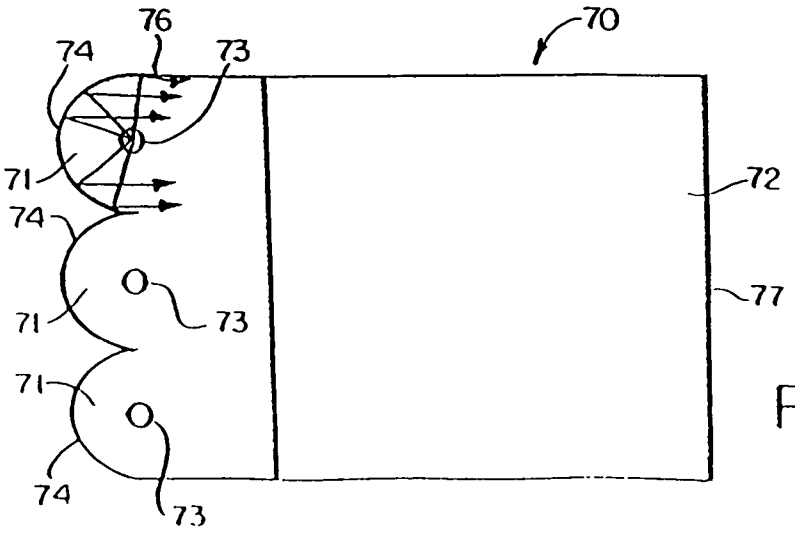

FIG. 12

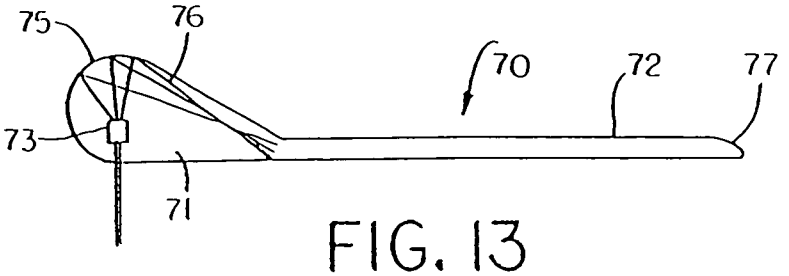

FIG. 13

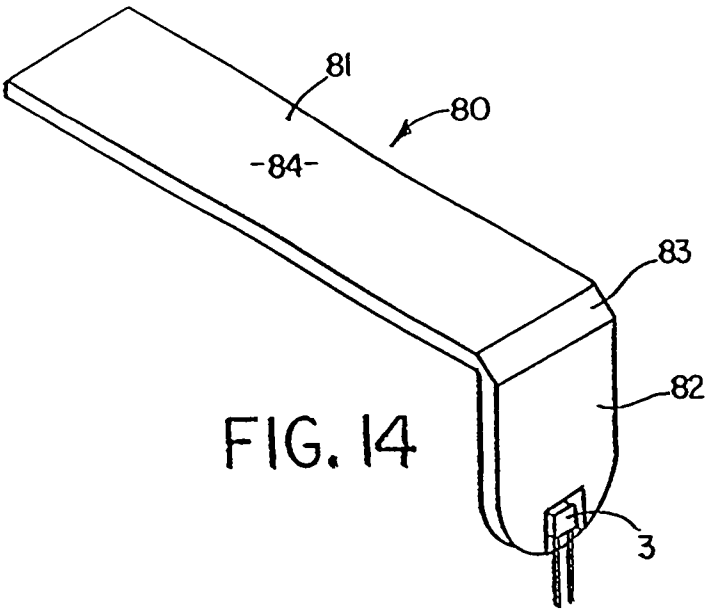

FIG. 14

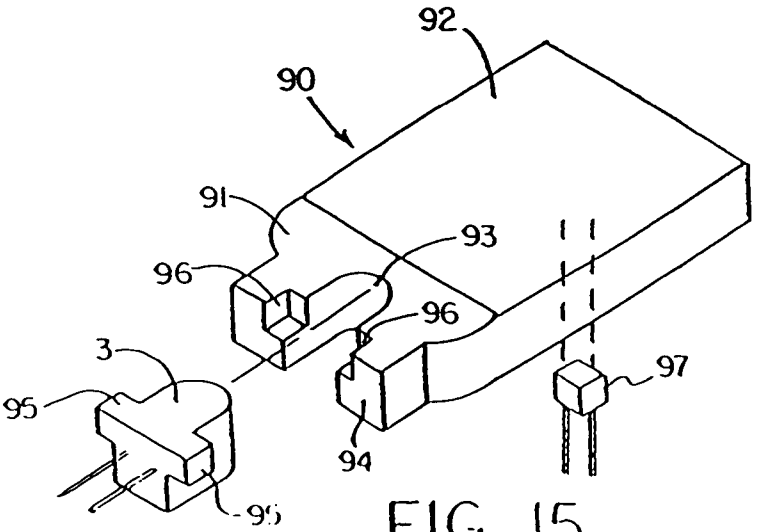

FIG. 15

LIGHT EMITTING PANEL ASSEMBLIES

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 10/784,527, filed Feb. 23, 2004, which is a division of U.S. patent application Ser. No. 09/256,275, filed Feb. 23, 1999, now U.S. Pat. No. 6,712,481, dated Mar. 30, 2004, which is a continuation-in-part of U.S. patent application Ser. No. 08/778,089, filed Jan. 2, 1997, now U.S. Pat. No. 6,079,838, dated Jun. 27, 2000, which is a division of U.S. patent application Ser. No. 08/495,176, filed Jun. 27, 1995, now U.S. Pat. No. 5,613,751, dated Mar. 25, 1997.

BACKGROUND OF THE INVENTION

This invention relates generally, as indicated, to light emitting panel assemblies each including a transparent panel member for efficiently conducting light, and controlling the light conducted by the panel member to be emitted from one or more light output areas along the length thereof.

Light emitting panel assemblies are generally known. However, the present invention relates to several different light emitting panel assembly configurations which provide for better control of the light output from the panel assemblies and for more efficient utilization of light, which results in greater light output from the panel assemblies.

SUMMARY OF THE INVENTION

In accordance with one aspect of the invention, the light emitting panel assemblies include a light emitting panel member having a light transition area in which at least one light source is suitably mounted for transmission of light to the light input surface of the panel member.

In accordance with another aspect of the invention, the light source is desirably embedded, potted or bonded to the light transition area to eliminate any air gaps, decrease surface reflections and/or eliminate any lens effect between the light source and light transition area, thereby reducing light loss and increasing the light output from the panel assembly.

In accordance with another aspect of the invention, the panel assemblies may include reflective or refractive surfaces for changing the path of a portion of the light, emitted from the light source, that would not normally enter the panel members at an acceptable angle that allows the light to remain in the panel members for a longer period of time and/or increase the efficiency of the panel members.

In accordance with another aspect of the invention, the light emitting panel members include a pattern of light extracting deformities or disruptions which provide a desired light output distribution from the panel members by changing the angle of refraction of a portion of the light from one or more light output areas of the panel members.

In accordance with still another aspect of the invention, the light source may include multiple colored light sources for supplying light to one or more light output areas, and for providing a colored or white light output distribution.

In accordance with yet another aspect of the invention, the panel assemblies include a transition area for mixing the multiple colored lights, prior to the light entering the panel members, in order to effect a desired colored or white light output distribution.

The various light emitting panel assemblies of the present invention are very efficient panel assemblies that may be used to produce increased uniformity and higher light output from the panel members with lower power requirements, and allow the panel members to be made thinner and/or longer, and/or of various shapes and sizes.

To the accomplishment of the foregoing and related ends, the invention then comprises the features hereinafter fully described and particularly pointed out in the claims, the following description and the annexed drawings setting forth in detail certain illustrative embodiments of the invention, these being indicative, however, of but several of the various ways in which the principles of the invention may be employed.

BRIEF DESCRIPTION OF THE DRAWINGS

In the annexed drawings:

FIGS. **1** through **3** are schematic perspective views of three different forms of light emitting panel assemblies in accordance with this invention;

FIG. **4***a* is an enlarged plan view of a portion of a light output area of a panel assembly showing one form of pattern of light extracting deformities on the light output area;

FIGS. **4***b, c* and *d* are enlarged schematic perspective views of a portion of a light output area of a panel assembly showing other forms of light extracting deformities formed in or on the light output area;

FIG. **5** is an enlarged transverse section through the light emitting panel assembly of FIG. **3** taken generally on the plane of the line **5-5** thereof;

FIG. **6** is a schematic perspective view of another form of light emitting panel assembly in accordance with this invention;

FIG. **7** is a schematic top plan view of another form of light emitting panel assembly in accordance with this invention;

FIG. **8** is a schematic perspective view of another form of light emitting panel assembly in accordance with this invention;

FIG. **9** is a schematic top plan view of another form of light emitting panel assembly in accordance with this invention;

FIG. **10** is a schematic top plan view of still another form of light emitting panel assembly in accordance with this invention;

FIG. **11** is a side elevation view of the light emitting panel assembly of FIG. **10**;

FIG. **11***a* is a fragmentary side elevation view showing a tapered or rounded end on the panel member in place of the prismatic surface shown in FIGS. **10** and **11**;

FIG. **12** is a schematic top plan view of another form of light emitting panel assembly in accordance with this invention;

FIG. **13** is a schematic side elevation view of the light emitting panel assembly of FIG. **12**; and

FIGS. **14** and **15** are schematic perspective views of still other forms of light emitting panel assemblies in accordance with this invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now in detail to the drawings, and initially to FIG. **1**, there is schematically shown one form of light emitting panel assembly **1** in accordance with this invention including a transparent light emitting panel **2** and one or more light sources **3** which emit light in a predetermined pattern in a light transition member or area **4** used to make the transition from the light source **3** to the light emitting panel **2**, as well known in the art. The light that is transmitted by the light transition area **4** to the transparent light emitting panel **2** may be emitted along the entire length of the panel or from one or

more light output areas along the length of the panel as desired to produce a desired light output distribution to fit a particular application.

In FIG. **1** the light transition area **4** is shown as an integral extension of one end of the light emitting panel **2** and as being generally rectangular in shape. However, the light transition area may be of other shapes suitable for embedding, potting, bonding or otherwise mounting the light source. Also, reflective or refractive surfaces may be provided to increase efficiency. Moreover, the light transition area **4** may be a separate piece suitably attached to the light input surface **13** of the panel member if desired. Also, the sides of the light transition area may be curved to more efficiently reflect or refract a portion of the light emitted from the light source through the light emitting panel at an acceptable angle.

FIG. **2** shows another form of light emitting panel assembly **5** in accordance with this invention including a panel light transition area **6** at one end of the light emitting panel **7** with sides **8**, **9** around and behind the light source **3** shaped to more efficiently reflect and/or refract and focus the light emitted from the light source **3** that impinges on these surfaces back through the light transition area **6** at an acceptable angle for entering the light input surface **18** at one end of the light emitting panel **7**. Also, a suitable reflective material or coating **10** may be provided on the portions of the sides of the light transition areas of the panel assemblies of FIGS. **1** and **2** on which a portion of the light impinges for maximizing the amount of light or otherwise changing the light that is reflected back through the light transition areas and into the light emitting panels.

The panel assemblies shown in FIGS. **1** and **2** include a single light source **3**, whereas FIG. **3** shows another light emitting panel assembly **11** in accordance with this invention including two light sources **3**. Of course, it will be appreciated that the panel assemblies of the present invention may be provided with any number of light sources as desired, depending on the particular application.

The panel assembly **11** of FIG. **3** includes a light transition area **12** at one end of the light emitting panel **14** having reflective and/or refractive surfaces **15** around and behind each light source **3**. These surfaces **15** may be appropriately shaped including for example curved, straight and/or faceted surfaces, and if desired, suitable reflective materials or coatings may be provided on portions of these surfaces to more efficiently reflect and/or refract and focus a portion of the light emitted for example from an incandescent light source which emits light in a 360° pattern through the light transition areas **12** into the light input surface **19** of the light emitting panel **14**.

The light sources **3** may be mechanically held in any suitable manner in slots, cavities or openings **16** machined, molded or otherwise formed in the light transition areas of the panel assemblies. However, preferably the light sources **3** are embedded, potted or bonded in the light transition areas in order to eliminate any air gaps or air interface surfaces between the light sources and surrounding light transition areas, thereby reducing light loss and increasing the light output emitted by the light emitting panels. Such mounting of the light sources may be accomplished, for example, by bonding the light sources **3** in the slots, cavities or openings **16** in the light transition areas using a sufficient quantity of a suitable embedding, potting or bonding material **17**. The slots, cavities or openings **16** may be on the top, bottom, sides or back of the light transition areas. Bonding can also be accomplished by a variety of methods that do not incorporate extra material, for example, thermal bonding, heat staking, ultrasonic or plastic welding or the like. Other methods of bonding include insert molding and casting around the light source(s).

A transparent light emitting material of any suitable type, for example acrylic or polycarbonate, may be used for the light emitting panels. Also, the panels may be substantially flat, or curved, may be a single layer or multi-layers, and may have different thicknesses and shapes. Moreover, the panels may be flexible, or rigid, and may be made out of a variety of compounds. Further, the panels may be hollow, filled with liquid, air, or be solid, and may have holes or ridges in the panels.

Each light source **3** may also be of any suitable type including, for example, any of the types disclosed in U.S. Pat. Nos. 4,897,771 and 5,005,108, assigned to the same assignee as the present application, the entire disclosures of which are incorporated herein by reference. In particular, the light sources **3** may be an arc lamp, an incandescent bulb which also may be colored, filtered or painted, a lens end bulb, a line light, a halogen lamp, a light emitting diode (LED), a chip from an LED, a neon bulb, a fluorescent tube, a fiber optic light pipe transmitting from a remote source, a laser or laser diode, or any other suitable light source. Additionally, the light sources **3** may be a multiple colored LED, or a combination of multiple colored radiation sources in order to provide a desired colored or white light output distribution. For example, a plurality of colored lights such as LEDs of different colors (red, blue, green) or a single LED with multiple colored chips may be employed to create white light or any other colored light output distribution by varying the intensities of each individual colored light.

A pattern of light extracting deformities or disruptions may be provided on one or both sides of the panel members or on one or more selected areas on one or both sides of the panel members, as desired. FIG. **4***a* schematically shows one such light surface area **20** on which a pattern of light extracting deformities or disruptions **21** is provided. As used herein, the term deformities or disruptions are used interchangeably to mean any change in the shape or geometry of the panel surface and/or coating or surface treatment that causes a portion of the light to be emitted. The pattern of light extracting deformities **21** shown in FIG. **4***a* includes a variable pattern which breaks up the light rays such that the internal angle of reflection of a portion of the light rays will be great enough to cause the light rays either to be emitted out of the panel through the side or sides on which the light extracting deformities **21** are provided or reflected back through the panel and emitted out the other side.

These deformities or disruptions **21** can be produced in a variety of manners, for example, by providing a painted pattern, an etched pattern, a machined pattern, a printed pattern, a hot stamped pattern, or a molded pattern or the like on selected light output areas of the panel members. An ink or printed pattern may be applied for example by pad printing, silk screening, ink jet, heat transfer film process or the like. The deformities may also be printed on a sheet or film which is used to apply the deformities to the panel member. This sheet or film may become a permanent part of the light panel assembly for example by attaching or otherwise positioning the sheet or film against one or both sides of the panel member similar to the sheet or film **27** shown in FIGS. **3** and **5** in order to produce a desired effect.

By varying the density, opaqueness or translucence, shape, depth, color, area, index of refraction, or type of deformities **21** on an area or areas of the panels, the light output of the panels can be controlled. The deformities or disruptions may be used to control the percent of light emitted from any area of the panels. For example, less and/or smaller size deformi-

ties **21** may be placed on panel areas where less light output is wanted. Conversely, a greater percentage of and/or larger deformities may be placed on areas of the panels where greater light output is desired.

Varying the percentages and/or size of deformities in different areas of the panel is necessary in order to provide a uniform light output distribution. For example, the amount of light traveling through the panels will ordinarily be greater in areas closer to the light source than in other areas further removed from the light source. A pattern of light extracting deformities **21** may be used to adjust for the light variances within the panel members, for example, by providing a denser concentration of light extracting deformities with increased distance from the light source **3** thereby resulting in a more uniform light output distribution from the light emitting panels.

The deformities **21** may also be used to control the output ray angle distribution of the emitted light to suit a particular application. For example, if the panel assemblies are used to provide a liquid crystal display backlight, the light output will be more efficient if the deformities **21** cause the light rays to emit from the panels at predetermined ray angles such that they will pass through the liquid crystal display with low loss.

Additionally, the pattern of light extracting deformities may be used to adjust for light output variances attributed to light extractions of the panel members. The pattern of light extracting deformities **21** may be printed on the light output areas utilizing a wide spectrum of paints, inks, coatings, epoxies, or the like, ranging from glossy to opaque or both, and may employ half-tone separation techniques to vary the deformity **21** coverage. Moreover, the pattern of light extracting deformities **21** may be multiple layers or vary in index of refraction.

Print patterns of light extracting deformities **21** may vary in shapes such as dots, squares, diamonds, ellipses, stars, random shapes, and the like, and are desirably 0.006 square inch per deformity/element or less. Also, print patterns that are 60 lines per inch or finer are desirably employed, thus making the deformities or shapes **21** in the print patterns nearly invisible to the human eye in a particular application thereby eliminating the detection of gradient or banding lines that are common to light extracting patterns utilizing larger elements. Additionally, the deformities may vary in shape and/or size along the length and/or width of the panel members. Also, a random placement pattern of the deformities may be utilized throughout the length and/or width of the panel members. The deformities may have shapes or a pattern with no specific angles to reduce moiré or other interference effects. Examples of methods to create these random patterns are printing a pattern of shapes using stochastic print pattern techniques, frequency modulated half tone patterns, or random dot half tones. Moreover, the deformities may be colored in order to effect color correction in the panel members. The color of the deformities may also vary throughout the panel members, for example to provide different colors for the same or different light output areas.

In addition to or in lieu of the patterns of light extracting deformities **21** shown in FIG. **4***a*, other light extracting deformities including prismatic surfaces, depressions or raised surfaces of various shapes using more complex shapes in a mold pattern may be molded, etched, stamped, thermoformed, hot stamped or the like into or on one or more areas of the panel member. FIGS. **4***b* and **4***c* show panel areas **22** on which prismatic surfaces **23** or depressions **24** are formed in the panel areas, whereas FIG. **4***d* shows prismatic or other reflective or refractive surfaces **25** formed on the exterior of the panel area. The prismatic surfaces, depressions or raised surfaces will cause a portion of the light rays contacted thereby to be emitted from the panel member. Also, the angles of the prisms, depressions or other surfaces may be varied to direct the light in different directions to produce a desired light output distribution or effect. Moreover, the reflective or refractive surfaces may have shapes or a pattern with no specific angles to reduce moiréor other interference effects.

As best seen in the cross sectional view of FIG. **5**, a back reflector (including trans reflectors) **26** may be attached or positioned against one side of the panel member **14** of FIG. **3** using a suitable adhesive **28** or other method in order to improve light output efficiency of the panel assembly **11** by reflecting the light emitted from that side back through the panel for emission through the opposite side. Additionally, a pattern of light extracting deformities **21**, **23**, **24** and/or **25** may be provided on one or both sides of the panel member in order to change the path of the light so that the internal critical angle is exceeded and a portion of the light is emitted from one or both sides of the panel. Moreover, a transparent film, sheet or plate **27** may be attached or positioned against the side or sides of the panel member from which light is emitted using a suitable adhesive **28** or other method in order to produce a desired effect.

The member **27** may be used to further improve the uniformity of the light output distribution. For example, the member **27** may be a colored film, a diffuser, or a label or display, a portion of which may be a transparent overlay that may be colored and/or have text or an image thereon.

If adhesive **28** is used to adhere the back reflector **26** and/or film **27** to the panel, the adhesive is preferably applied only along the side edges of the panel, and if desired the end edge opposite the light transition areas **12**, but not over the entire surface area or areas of the panel because of the difficulty in consistently applying a uniform coating of adhesive to the panel. Also, the adhesive changes the internal critical angle of the light in a less controllable manner than the air gaps **30** (see FIG. **5**) which are formed between the respective panel surfaces and the back reflector **26** and/or film **27** when only adhered along the peripheral edges. Additionally, longer panel members are achievable when air gaps **30** are used. If adhesive were to be used over the entire surface, the pattern of deformities could be adjusted to account for the additional attenuation in the light caused by the adhesive.

Referring further to FIG. **2**, the panel assembly **5** shown therein also includes molded posts **31** at one or more corners of the panel **7** (four such posts being shown) which may be used to facilitate mounting of the panel assembly and providing structural support for other parts or components, for example, a display panel such as a liquid crystal display panel as desired.

FIG. **6** shows another form of light emitting panel assembly **32** in accordance with this invention including a panel member **33**, one or more light sources **3**, and one or more light output areas **34**. In addition, the panel assembly **32** includes a tray **35** having a cavity or recess **36** in which the panel assembly **32** is received. The tray **35** may act as a back reflector as well as end edge and/or side edge reflectors for the panel **33** and side and/or back reflectors **37** for the light sources **3**. Additionally, one or more secondary reflective or refractive surfaces **38** may be provided on the panel member **33** and/or tray **35** to reflect a portion of the light around one or more corners or curves in a non-rectangular shaped panel member **33**. These secondary reflective/refractive surfaces **38** may be flat, angled, faceted or curved, and may be used to extract a portion of the light away from the panel member in a prede-

termined pattern. FIG. **6** also shows multiple light output areas **34** on the panel member that emit light from one or more light sources **3**.

FIG. **7** is a schematic illustration of still another form of light emitting panel assembly **40** in accordance with this invention including a panel member **41** having one or more light output areas **42** and one or more light transition areas (mixing areas) **43** containing a plurality of light sources **3** at one or both ends of the panel. Each transition area mixes the light from one or more light sources having different colors and/or intensities. In this particular embodiment, each of the light sources **3** desirably employs three colored LEDs (red, blue, green) in each transition mixing area **43** so that the light from the three LEDs can be mixed to produce a desired light output color that will be emitted from the light output area **42**. Alternatively, each light source may be a single LED having multiple colored chips bonded to the lead film. Also, two colored LEDs or a single LED having two colored chips may be used for a particular application. By varying the intensities of the individual respective LEDs, virtually any colored light output or white light distribution can be achieved.

FIG. **8** shows yet another form of light emitting panel assembly **45** in accordance with this invention including a light emitting panel member **46** and a light source **3** in a light transition area **48** integral with one end of the panel member. In this particular embodiment, the panel member **46** is three-dimensionally curved, for example, such that light rays may be emitted in a manner that facilitates aesthetic design of a lighted display.

FIG. **9** schematically shows another form of light emitting panel assembly **50** in accordance with this invention, including a panel member **51** having multiple light output areas **52**, and mounting posts and/or mounting tabs **53**. This particular panel assembly **50** may serve as a structural member to support other parts or components as by providing holes or cavities **54**, **55** in the panel member **51** which allow for the insertion of modular components or other parts into the panel member. Moreover, a separate cavity or recess **56** may be provided in the panel member **51** for receipt of a correspondingly shaped light transition area **57** having one or more light sources **3** embedded, bonded, cast, insert molded, epoxied, or otherwise mounted or positioned therein and a curved reflective or refractive surface **58** on the transition area **57** and/or wall of the cavity or recess **56** to redirect a portion of the light in a predetermined manner. In this way the light transition area **57** and/or panel member may be in the form of a separate insert which facilitates the easy placement of the light source in a modular manner. A reflector **58** may be placed on the reflective or refractive surface of the cavity or recess **56** or insert **57**. Where the reflector **58** is placed on the reflective or refractive surface of the cavity or recess **56**, the cavity or recess may act as a mold permitting transparent material from which the transition area **57** is made to be cast around one or more light sources **3**.

FIGS. **10** and **11** schematically show another form of light emitting panel assembly **60** in accordance with this invention including a panel member **61** having one or more light output areas **62**. In this particular embodiment, an off-axis light transition area **63** is provided that is thicker in cross section than the panel member to permit use of one or more light sources **3** embedded or otherwise mounted in the light transition area that are dimensionally thicker than the panel member. Also, a three-dimensional reflective surface **64** (FIG. **11**) may be provided on the transition area **63**. Moreover, a prism **65** (FIG. **11**) or tapered, rounded, or otherwise shaped end **66** (FIG. **11***a*) may be provided at the end of the panel opposite the light sources **3** to perform the function of an end reflector. The light sources **3** may be oriented at different angles relative to each other and offset to facilitate better mixing of the light rays **67** in the transition area **63** as schematically shown in FIG. **10** and/or to permit a shorter length transition area **63** to be used.

FIGS. **12** and **13** schematically show still another form of light emitting panel assembly **70** in accordance with this invention which includes one or more light transition areas **71** at one or both ends of the panel member **72** each containing a single light source **73**. The transition area or areas **71** shown in FIGS. **12** and **13** collect light with multiple or three-dimensional surfaces and/or collect light in more than one plane. For example each transition area **71** shown in FIGS. **12** and **13** has elliptical and parabolic shape surfaces **74** and **75** in different planes for directing the light rays **76** into the panel member at a desired angle.

Providing one or more transition areas at one or both ends of the panel member of any desired dimension to accommodate one or more light sources, with reflective and/or refractive surfaces on the transition areas for redirecting the light rays into the panel member at relatively low angles allows the light emitting panel member to be made much longer and thinner than would otherwise be possible. For example the panel members of the present invention may be made very thin, i.e., 0.125 inch thick or less.

FIG. **14** schematically illustrates still another form of light emitting panel assembly **80** in accordance with this invention including a light emitting panel **81** and one or more light sources **3** positioned, embedded, potted, bonded or otherwise mounted in a light transition area **82** that is at an angle relative to the panel member **81** to permit more efficient use of space. An angled or curved reflective or refractive surface **83** is provided at the junction of the panel member **81** with the transition area **82** in order to reflect/refract light from the light source **3** into the body of the panel member **81** for emission of light from one or more light emitting areas **84** along the length of the panel member.

FIG. **15** schematically illustrates still another form of light emitting panel assembly **90** in accordance with this invention including a light transition area **91** at one or both ends of a light emitting panel member **92** containing a slot **93** for sliding receipt of an LED or other suitable light source **3**. Preferably the slot **93** extends into the transition area **91** from the back edge **94**, whereby the light source **3** may be slid and/or snapped in place in the slot from the back, thus allowing the transition area to be made shorter and/or thinner. The light source **3** may be provided with wings, tabs or other surfaces **95** for engagement in correspondingly shaped recesses or grooves **96** or the like in the transition area **91** for locating and, if desired, securing the light source in place. Also, the light source **3** may be embedded, potted, bonded or otherwise secured within the slot **93** in the light transition area **91** of the panel member **92**. Light from a secondary light source **97** may be projected through the panel member **92** for indication or some other effect.

The various light emitting panel assemblies disclosed herein may be used for a great many different applications including for example LCD back lighting or lighting in general, decorative and display lighting, automotive lighting, dental lighting, phototherapy or other medical lighting, membrane switch lighting, and sporting goods and apparel lighting or the like. Also the panel assemblies may be made such that the panel members and deformities are transparent without a back reflector. This allows the panel assemblies to be used for example to front light an LCD or other display such that the display is viewed through the transparent panel members.

Although the invention has been shown and described with respect to certain preferred embodiments, it is obvious that equivalent alterations and modifications will occur to others skilled in the art upon the reading and understanding of the specification. The present invention includes all such equivalent alterations and modifications, and is limited only by the scope of the claims.

What is claimed is:

1. A light emitting panel assembly comprising at least a light emitting panel member having a light entrance surface and a light emitting surface, at least one LED light source positioned near or against the light entrance surface, and a tray or housing having a cavity or recess in which the panel member is entirely received, wherein the panel member has a pattern of light extracting deformities on or in at least one surface to cause light to be emitted from the light emitting surface of the panel member, and the tray or housing includes end walls and side walls that act as end edge reflectors and side edge reflectors for the panel member to reflect light that would otherwise exit the panel member through an end edge and/or side edge back into the panel member and toward the pattern of light extracting deformities for causing additional light to be emitted from the light emitting surface of the panel member, wherein the tray or housing provides structural support to the panel member and has posts, tabs, or other structural features that provide a mount for mounting of the assembly into a larger assembly or device.

2. The assembly of claim **1** wherein the tray or housing includes a bottom wall that acts as a back reflector for the panel member.

3. The assembly of claim **1** wherein the tray or housing provides a support for supporting and/or positioning a film near the panel member.

4. The assembly of claim **3** wherein the film is at least one of a diffuser and a brightness enhancing film.

5. The assembly of claim **1** further comprising a film positioned near the light emitting surface of the panel member for changing the output ray angle distribution of the emitted light to fit a particular application.

6. The assembly of claim **1** wherein the light entrance surface is faceted to alter the light output distribution of the LED as the light enters the panel member.

7. A light emitting panel assembly comprising at least a light emitting panel member having a light entrance surface and a light emitting surface, at least one LED light source positioned near or against the light entrance surface, and a tray or housing having a cavity or recess in which the panel member is entirely received, wherein the panel member has a pattern of light extracting deformities on or in at least one surface to cause light to be emitted from the light emitting surface of the panel member, and the tray or housing includes end walls and side walls that act as end edge reflectors and side edge reflectors for the panel member to reflect light that would otherwise exit the panel member through an end edge and/or side edge back into the panel member and toward the pattern of light extracting deformities for causing additional light to be emitted from the light emitting surface of the panel member, wherein the tray or housing has posts, tabs or other structural features that provide a mount or structural support for at least one other part or component, and the tray or housing provides structural support to the panel member.

8. The assembly of claim **7** wherein the other part or component is a liquid crystal display.

9. The assembly of claim **7** wherein the other part or component is a printed circuit.

10. The assembly of claim **7** wherein the film is at least one of a diffuser and a brightness enhancing film.

11. The assembly of claim **7** further comprising a film positioned near the light emitting surface of the panel member for changing the output ray angle distribution of the emitted light to fit a particular application.

12. The assembly of claim **7** wherein the light entrance surface is faceted to alter the light output distribution of the LED as the light enters the panel member.

13. A light emitting panel assembly comprising at least a light emitting panel member having a light entrance surface and a light emitting surface, at least one LED light source positioned near or against the light entrance surface, and a tray or housing having a cavity or recess in which the panel member is entirely received, wherein the panel member has a pattern of light extracting deformities on or in at least one surface to cause light to be emitted from the light emitting surface of the panel member, and the tray or housing includes end walls and side walls that act as end edge reflectors and side edge reflectors for the panel member to reflect light that would otherwise exit the panel member through an end edge and/or side edge back into the panel member and toward the pattern of light extracting deformities for causing additional light to be emitted from the light emitting surface of the panel member, and an additional component overlaying the panel member, the panel member having at least one of a tab, hole, cavity, or protrusion that positions the tray or housing relative to the panel member.

14. The assembly of claim **13** wherein the tray or housing includes at least one of a recess or cavity for positioning the panel member entirely within the recess or cavity.

15. The assembly of claim **13** wherein the additional component is a display panel.

16. The assembly of claim **13** wherein the additional component is a film or substrate.

17. A light emitting panel assembly comprising at least a light emitting panel member having a light entrance surface and a light emitting surface, at least one LED light source positioned near or against the light entrance surface, and a tray or housing having a cavity or recess in which the panel member is entirely received, wherein the panel member has a pattern of light extracting deformities on or in at least one surface to cause light to be emitted from the light emitting surface of the panel member, and the tray or housing includes end walls and side walls that act as end edge reflectors and side edge reflectors for the panel member to reflect light that would otherwise exit the panel member through an end edge and/or side edge back into the panel member and toward the pattern of light extracting deformities for causing additional light to be emitted from the light emitting surface of the panel member, and an additional component overlying the panel member, the panel member having at least one of a tab, hole, cavity or protrusion that positions the additional component relative to the panel member, wherein the at least one of a tab, hole, cavity, or protrusion holds the additional component away from the panel member to create an air gap between the panel member and the additional component.

18. The assembly of claim **17** wherein the protrusion is molded into the panel member and extends outward therefrom.

19. The assembly of claim **18** wherein the protrusion comprises a post extending outward from the panel member.

20. The assembly of claim **18** wherein the additional component is a film or substrate.

21. The assembly of claim **17** wherein the light source is positioned relative to the panel member by the at least one of a tab, hole, cavity, or protrusion.

22. The assembly of claim **21** wherein the light source has a tab and the panel member has a recess to receive the tab of the light source.

23. The assembly of claim **17** wherein the tray includes at least one of a recess or cavity for positioning the panel member entirely within the recess or cavity.

24. The assembly of claim **17** wherein the additional component is a display panel.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 7,434,974 B2
APPLICATION NO. : 11/378080
DATED : October 14, 2008
INVENTOR(S) : Jeffery R. Parker

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 9,
Line 66, replace "7" with --11--.

Signed and Sealed this

Second Day of December, 2008

JON W. DUDAS
Director of the United States Patent and Trademark Office

EXHIBIT B

US007537370B2

(12) **United States Patent**
Parker

(10) **Patent No.: US 7,537,370 B2**
(45) **Date of Patent: *May 26, 2009**

(54) **LIGHT EMITTING PANEL ASSEMBLIES**

(75) Inventor: **Jeffery R. Parker**, Richfield, OH (US)

(73) Assignee: **Solid State Opto Limited** (VG)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **11/548,330**

(22) Filed: **Oct. 11, 2006**

(65) **Prior Publication Data**

US 2007/0153549 A1 Jul. 5, 2007

Related U.S. Application Data

(60) Division of application No. 10/784,527, filed on Feb. 23, 2004, now Pat. No. 7,160,015, which is a division of application No. 09/256,275, filed on Feb. 23, 1999, now Pat. No. 6,712,481, which is a continuation-in-part of application No. 08/778,089, filed on Jan. 2, 1997, now Pat. No. 6,079,838, which is a division of application No. 08/495,176, filed on Jun. 27, 1995, now Pat. No. 5,613,751.

(51) **Int. Cl.**
F21V 8/00 (2006.01)

(52) **U.S. Cl.** **362/607**; 362/618; 362/619; 362/620

(58) **Field of Classification Search** 362/603, 362/606–609, 617–621, 623–628
See application file for complete search history.

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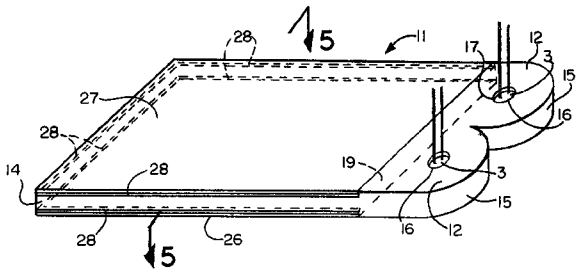
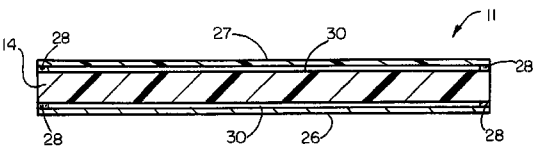
(57) **ABSTRACT**

Light emitting panel assemblies include an optical panel member having a pattern of light extracting deformities on or in one or both sides to cause light to be emitted in a predetermined output distribution. The pattern of light extracting deformities on or in one side may have two or more different types or shapes of deformities and at least one of the types or shapes may vary along the length or width of the panel member. Where the light extracting deformities are on or in both sides, at least some of the deformities on or in one side may be of a different type or shape or vary in a different way or manner than the deformities on or in the other side.

48 Claims, 4 Drawing Sheets





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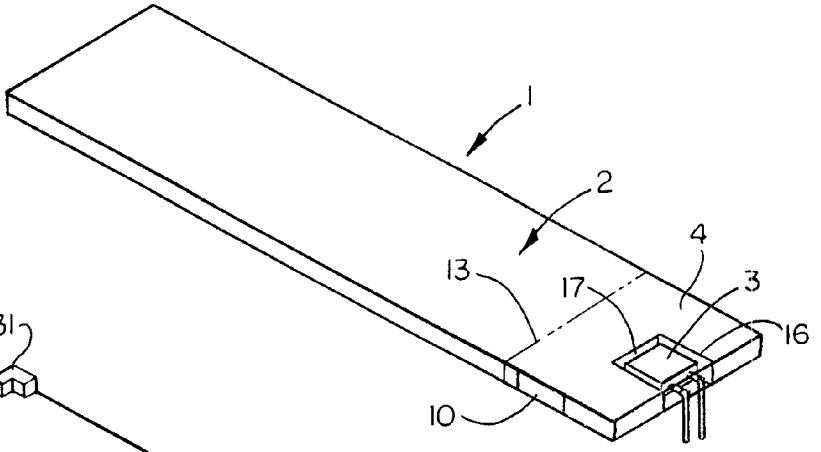

FIG. 1

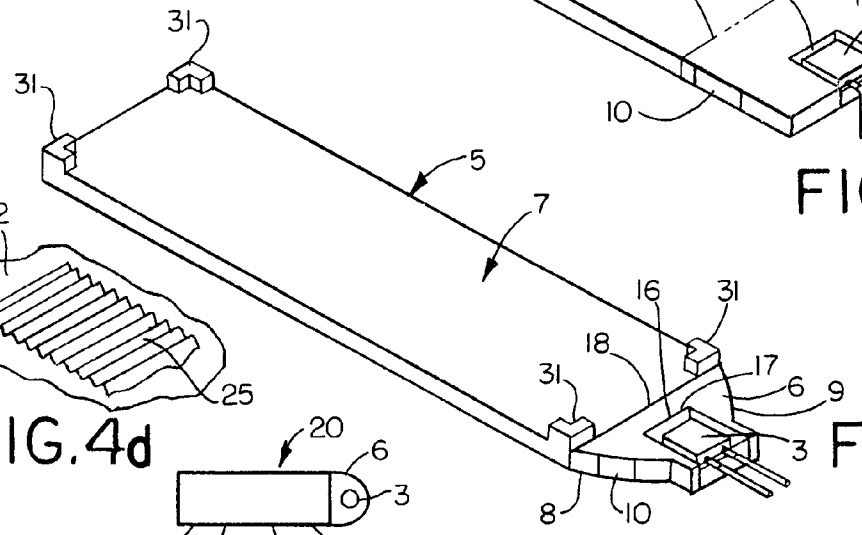

FIG. 2

FIG. 4d

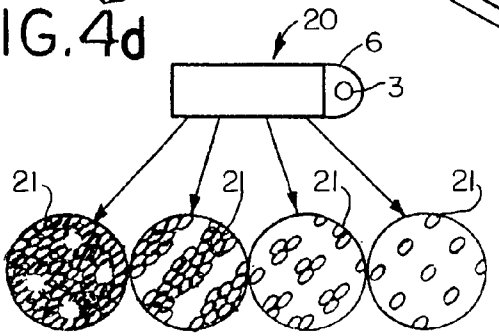

FIG. 4a

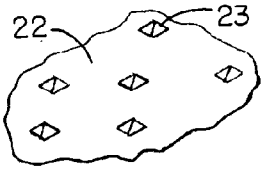

FIG. 4b

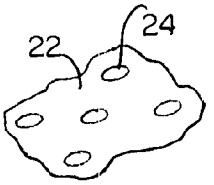

FIG. 4c

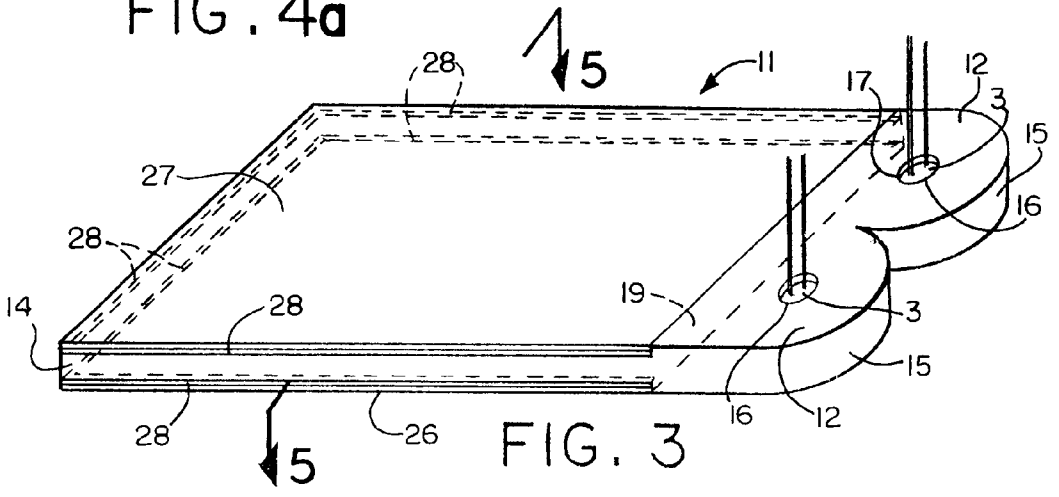

FIG. 3

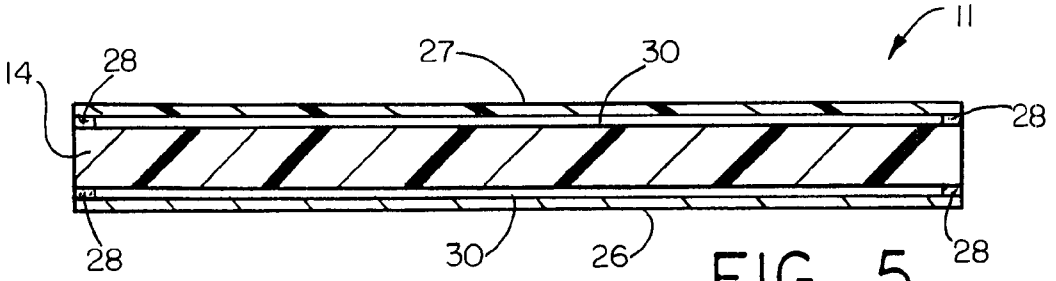

FIG. 5

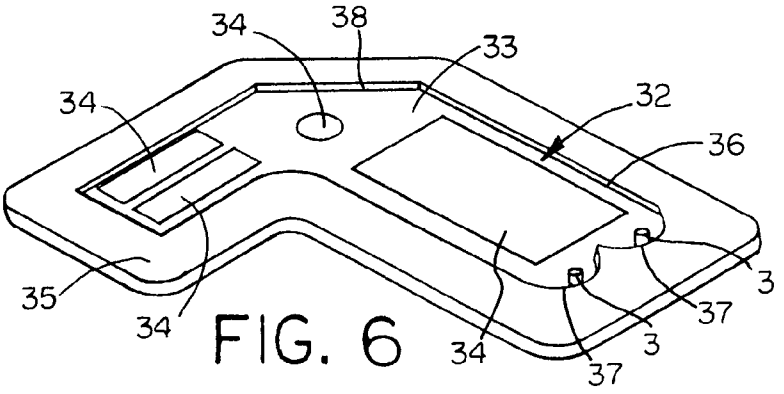

FIG. 6

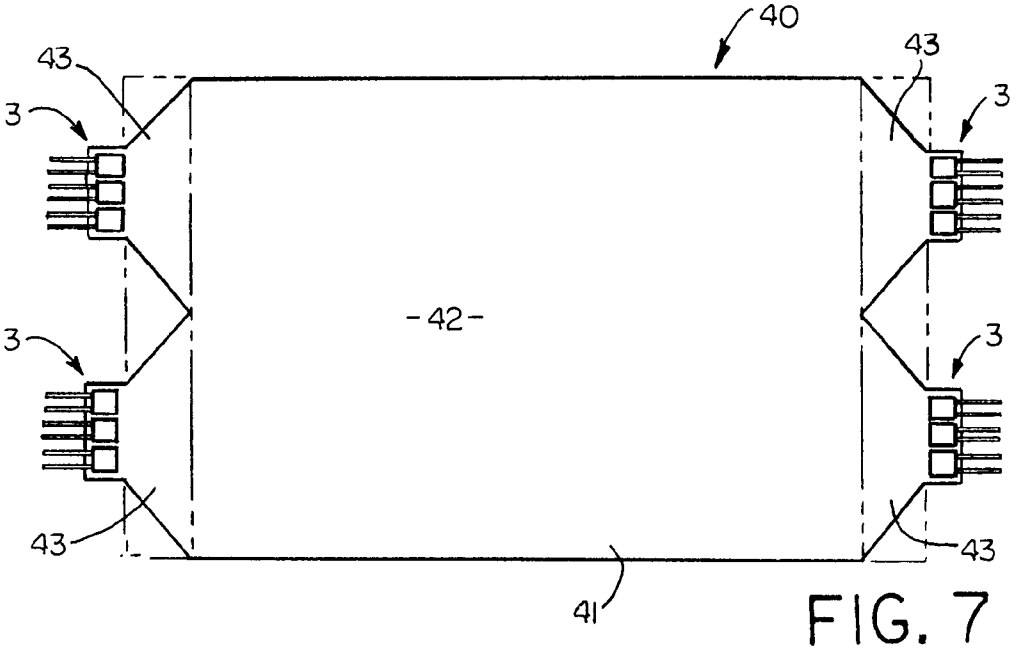

FIG. 7

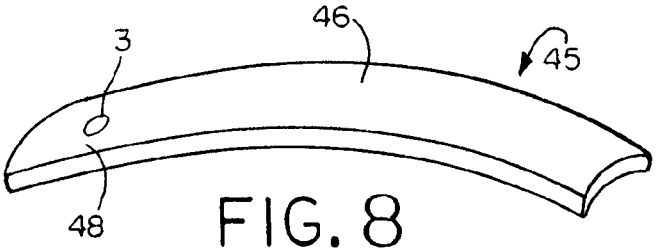

FIG. 8

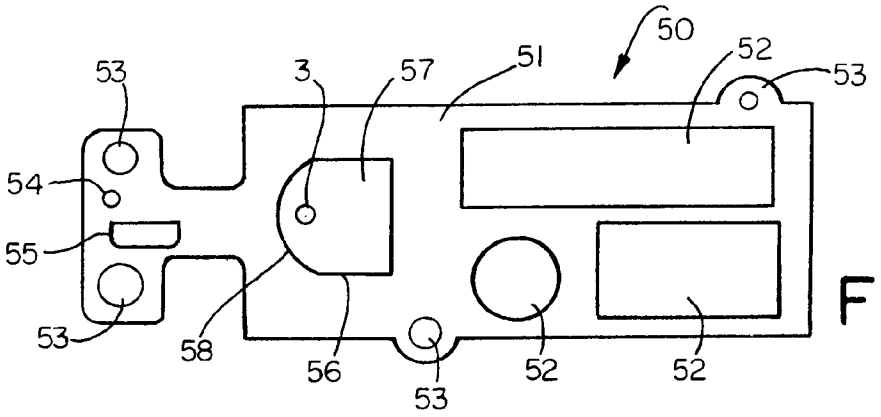

FIG. 9

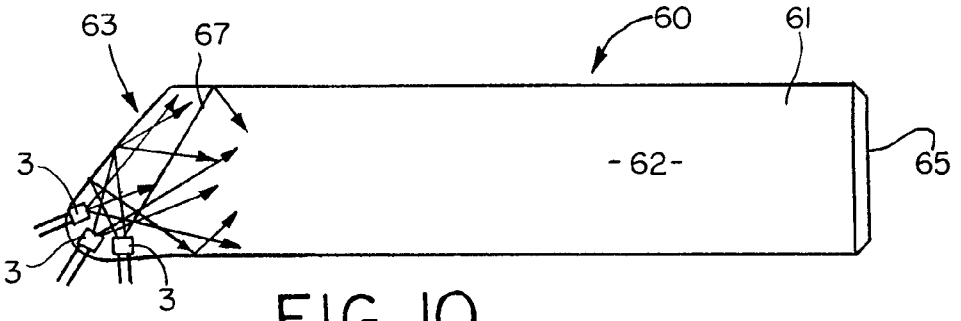

FIG. 10

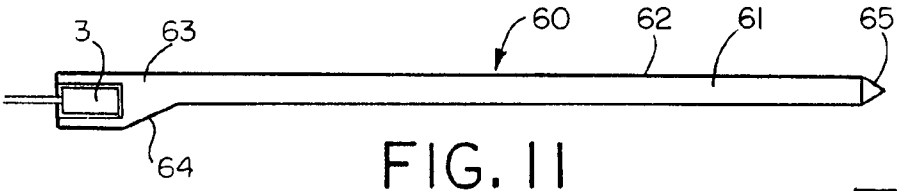

FIG. 11

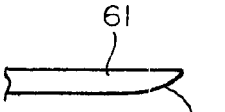

FIG. 11a

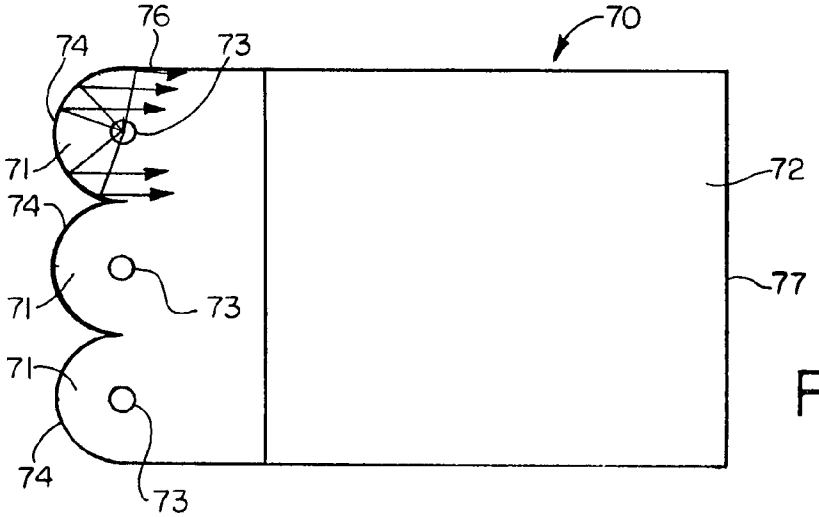

FIG. 12

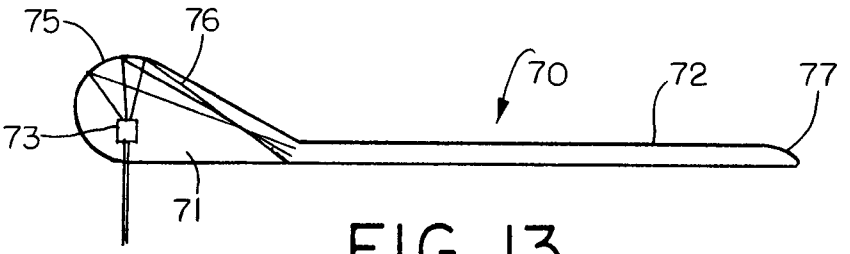

FIG. 13

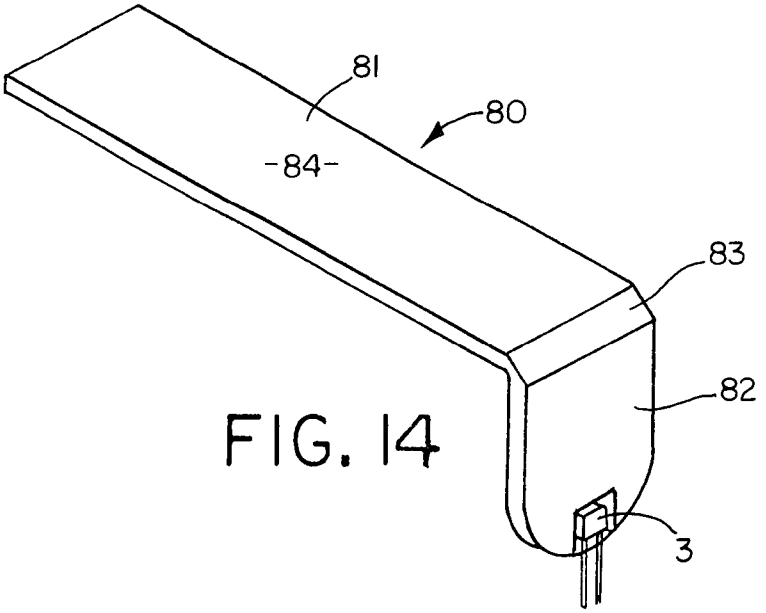

FIG. 14

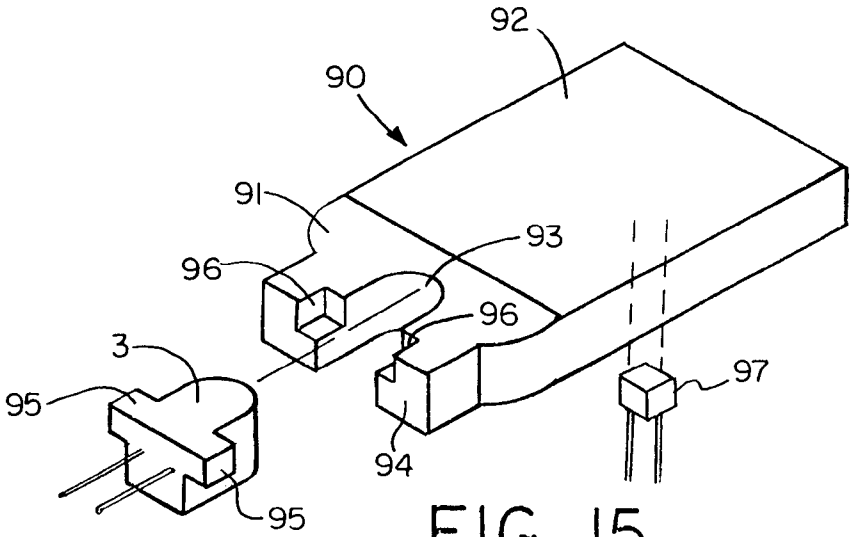

FIG. 15

LIGHT EMITTING PANEL ASSEMBLIES

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a division of U.S. patent application Ser. No. 10/784,527, filed Feb. 23, 2004, which is a division of U.S. patent application Ser. No. 09/256,275, filed Feb. 23, 1999, now U.S. Pat. No. 6,712,481, dated Mar. 30, 2004, which is a continuation-in-part of U.S. patent application Ser. No. 08/778,089, filed Jan. 2, 1997, now U.S. Pat. No. 6,079,838, dated Jun. 27, 2000, which is a division of U.S. patent application Ser. No. 08/495,176, filed Jun. 27, 1995, now U.S. Pat. No. 5,613,751, dated Mar. 25, 1997.

BACKGROUND OF THE INVENTION

This invention relates generally, as indicated, to light emitting panel assemblies each including a transparent panel member for efficiently conducting light, and controlling the light conducted by the panel member to be emitted from one or more light output areas along the length thereof.

Light emitting panel assemblies are generally known. However, the present invention relates to several different light emitting panel assembly configurations which provide for better control of the light output from the panel assemblies and for more efficient utilization of light, which results in greater light output from the panel assemblies.

SUMMARY OF THE INVENTION

In accordance with one aspect of the invention, the light emitting panel assemblies include a light emitting panel member having a light transition area in which at least one light source is suitably mounted for transmission of light to the light input surface of the panel member.

In accordance with another aspect of the invention, the light source is desirably embedded, potted or bonded to the light transition area to eliminate any air gaps, decrease surface reflections and/or eliminate any lens effect between the light source and light transition area, thereby reducing light loss and increasing the light output from the panel assembly.

In accordance with another aspect of the invention, the panel assemblies may include reflective or refractive surfaces for changing the path of a portion of the light, emitted from the light source, that would not normally enter the panel members at an acceptable angle that allows the light to remain in the panel members for a longer period of time and/or increase the efficiency of the panel members.

In accordance with another aspect of the invention, the light emitting panel members include a pattern of light extracting deformities or disruptions which provide a desired light output distribution from the panel members by changing the angle of refraction of a portion of the light from one or more light output areas of the panel members.

In accordance with still another aspect of the invention, the light source may include multiple colored light sources for supplying light to one or more light output areas, and for providing a colored or white light output distribution.

In accordance with yet another aspect of the invention, the panel assemblies include a transition area for mixing the multiple colored lights, prior to the light entering the panel members, in order to effect a desired colored or white light output distribution.

The various light emitting panel assemblies of the present invention are very efficient panel assemblies that may be used to produce increased uniformity and higher light output from the panel members with lower power requirements, and allow the panel members to be made thinner and/or longer, and/or of various shapes and sizes.

To the accomplishment of the foregoing and related ends, the invention then comprises the features hereinafter fully described and particularly pointed out in the claims, the following description and the annexed drawings setting forth in detail certain illustrative embodiments of the invention, these being indicative, however, of but several of the various ways in which the principles of the invention may be employed.

BRIEF DESCRIPTION OF THE DRAWINGS

In the annexed drawings:

FIGS. **1** through **3** are schematic perspective views of three different forms of light emitting panel assemblies in accordance with this invention;

FIG. **4***a* is an enlarged plan view of a portion of a light output area of a panel assembly showing one form of pattern of light extracting deformities on the light output area;

FIGS. **4***b, c* and *d* are enlarged schematic perspective views of a portion of a light output area of a panel assembly showing other forms of light extracting deformities formed in or on the light output area;

FIG. **5** is an enlarged transverse section through the light emitting panel assembly of FIG. **3** taken generally on the plane of the line **5-5** thereof;

FIG. **6** is a schematic perspective view of another form of light emitting panel assembly in accordance with this invention;

FIG. **7** is a schematic top plan view of another form of light emitting panel assembly in accordance with this invention;

FIG. **8** is a schematic perspective view of another form of light emitting panel assembly in accordance with this invention;

FIG. **9** is a schematic top plan view of another form of light emitting panel assembly in accordance with this invention;

FIG. **10** is a schematic top plan view of still another form of light emitting panel assembly in accordance with this invention;

FIG. **11** is a side elevation view of the light emitting panel assembly of FIG. **10**;

FIG. **11***a* is a fragmentary side elevation view showing a tapered or rounded end on the panel member in place of the prismatic surface shown in FIGS. **10** and **11**;

FIG. **12** is a schematic top plan view of another form of light emitting panel assembly in accordance with this invention;

FIG. **13** is a schematic side elevation view of the light emitting panel assembly of FIG. **12**; and

FIGS. **14** and **15** are schematic perspective views of still other forms of light emitting panel assemblies in accordance with this invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now in detail to the drawings, and initially to FIG. **1**, there is schematically shown one form of light emitting panel assembly **1** in accordance with this invention including a transparent light emitting panel **2** and one or more light sources **3** which emit light in a predetermined pattern in a light transition member or area **4** used to make the transition from the light source **3** to the light emitting panel **2**, as well known in the art. The light that is transmitted by the light transition area **4** to the transparent light emitting panel **2** may be emitted along the entire length of the panel or from one or

more light output areas along the length of the panel as desired to produce a desired light output distribution to fit a particular application.

In FIG. **1** the light transition area **4** is shown as an integral extension of one end of the light emitting panel **2** and as being generally rectangular in shape. However, the light transition area may be of other shapes suitable for embedding, potting, bonding or otherwise mounting the light source. Also, reflective or refractive surfaces may be provided to increase efficiency. Moreover, the light transition area **4** may be a separate piece suitably attached to the light input surface **13** of the panel member if desired. Also, the sides of the light transition area may be curved to more efficiently reflect or refract a portion of the light emitted from the light source through the light emitting panel at an acceptable angle.

FIG. **2** shows another form of light emitting panel assembly **5** in accordance with this invention including a panel light transition area **6** at one end of the light emitting panel **7** with sides **8**, **9** around and behind the light source **3** shaped to more efficiently reflect and/or refract and focus the light emitted from the light source **3** that impinges on these surfaces back through the light transition area **6** at an acceptable angle for entering the light input surface **18** at one end of the light emitting panel **7**. Also, a suitable reflective material or coating **10** may be provided on the portions of the sides of the light transition areas of the panel assemblies of FIGS. **1** and **2** on which a portion of the light impinges for maximizing the amount of light or otherwise changing the light that is reflected back through the light transition areas and into the light emitting panels.

The panel assemblies shown in FIGS. **1** and **2** include a single light source **3**, whereas FIG. **3** shows another light emitting panel assembly **11** in accordance with this invention including two light sources **3**. Of course, it will be appreciated that the panel assemblies of the present invention may be provided with any number of light sources as desired, depending on the particular application.

The panel assembly **11** of FIG. **3** includes a light transition area **12** at one end of the light emitting panel **14** having reflective and/or refractive surfaces **15** around and behind each light source **3**. These surfaces **15** may be appropriately shaped including for example curved, straight and/or faceted surfaces, and if desired, suitable reflective materials or coatings may be provided on portions of these surfaces to more efficiently reflect and/or refract and focus a portion of the light emitted for example from an incandescent light source which emits light in a 360° pattern through the light transition areas **12** into the light input surface **19** of the light emitting panel **14**.

The light sources **3** may be mechanically held in any suitable manner in slots, cavities or openings **16** machined, molded or otherwise formed in the light transition areas of the panel assemblies. However, preferably the light sources **3** are embedded, potted or bonded in the light transition areas in order to eliminate any air gaps or air interface surfaces between the light sources and surrounding light transition areas, thereby reducing light loss and increasing the light output emitted by the light emitting panels. Such mounting of the light sources may be accomplished, for example, by bonding the light sources **3** in the slots, cavities or openings **16** in the light transition areas using a sufficient quantity of a suitable embedding, potting or bonding material **17**. The slots, cavities or openings **16** may be on the top, bottom, sides or back of the light transition areas. Bonding can also be accomplished by a variety of methods that do not incorporate extra material, for example, thermal bonding, heat staking, ultrasonic or plastic welding or the like. Other methods of bonding include insert molding and casting around the light source(s).

A transparent light emitting material of any suitable type, for example acrylic or polycarbonate, may be used for the light emitting panels. Also, the panels may be substantially flat, or curved, may be a single layer or multi-layers, and may have different thicknesses and shapes. Moreover, the panels may be flexible, or rigid, and may be made out of a variety of compounds. Further, the panels may be hollow, filled with liquid, air, or be solid, and may have holes or ridges in the panels.

Each light source **3** may also be of any suitable type including, for example, any of the types disclosed in U.S. Pat. Nos. 4,897,771 and 5,005,108, assigned to the same assignee as the present application, the entire disclosures of which are incorporated herein by reference. In particular, the light sources **3** may be an arc lamp, an incandescent bulb which also may be colored, filtered or painted, a lens end bulb, a line light, a halogen lamp, a light emitting diode (LED), a chip from an LED, a neon bulb, a fluorescent tube, a fiber optic light pipe transmitting from a remote source, a laser or laser diode, or any other suitable light source. Additionally, the light sources **3** may be a multiple colored LED, or a combination of multiple colored radiation sources in order to provide a desired colored or white light output distribution. For example, a plurality of colored lights such as LEDs of different colors (red, blue, green) or a single LED with multiple colored chips may be employed to create white light or any other colored light output distribution by varying the intensities of each individual colored light.

A pattern of light extracting deformities or disruptions may be provided on one or both sides of the panel members or on one or more selected areas on one or both sides of the panel members, as desired. FIG. **4***a* schematically shows one such light surface area **20** on which a pattern of light extracting deformities or disruptions **21** is provided. As used herein, the term deformities or disruptions are used interchangeably to mean any change in the shape or geometry of the panel surface and/or coating or surface treatment that causes a portion of the light to be emitted. The pattern of light extracting deformities **21** shown in FIG. **4***a* includes a variable pattern which breaks up the light rays such that the internal angle of reflection of a portion of the light rays will be great enough to cause the light rays either to be emitted out of the panel through the side or sides on which the light extracting deformities **21** are provided or reflected back through the panel and emitted out the other side.

These deformities or disruptions **21** can be produced in a variety of manners, for example, by providing a painted pattern, an etched pattern, a machined pattern, a printed pattern, a hot stamped pattern, or a molded pattern or the like on selected light output areas of the panel members. An ink or printed pattern may be applied for example by pad printing, silk screening, ink jet, heat transfer film process or the like. The deformities may also be printed on a sheet or film which is used to apply the deformities to the panel member. This sheet or film may become a permanent part of the light panel assembly for example by attaching or otherwise positioning the sheet or film against one or both sides of the panel member similar to the sheet or film **27** shown in FIGS. **3** and **5** in order to produce a desired effect.

By varying the density, opaqueness or translucence, shape, depth, color, area, index of refraction, or type of deformities **21** on an area or areas of the panels, the light output of the panels can be controlled. The deformities or disruptions may be used to control the percent of light emitted from any area of the panels. For example, less and/or smaller size deformi-

ties **21** may be placed on panel areas where less light output is wanted. Conversely, a greater percentage of and/or larger deformities may be placed on areas of the panels where greater light output is desired.

Varying the percentages and/or size of deformities in different areas of the panel is necessary in order to provide a uniform light output distribution. For example, the amount of light traveling through the panels will ordinarily be greater in areas closer to the light source than in other areas further removed from the light source. A pattern of light extracting deformities **21** may be used to adjust for the light variances within the panel members, for example, by providing a denser concentration of light extracting deformities with increased distance from the light source **3** thereby resulting in a more uniform light output distribution from the light emitting panels.

The deformities **21** may also be used to control the output ray angle distribution of the emitted light to suit a particular application. For example, if the panel assemblies are used to provide a liquid crystal display backlight, the light output will be more efficient if the deformities **21** cause the light rays to emit from the panels at predetermined ray angles such that they will pass through the liquid crystal display with low loss.

Additionally, the pattern of light extracting deformities may be used to adjust for light output variances attributed to light extractions of the panel members. The pattern of light extracting deformities **21** may be printed on the light output areas utilizing a wide spectrum of paints, inks, coatings, epoxies, or the like, ranging from glossy to opaque or both, and may employ half-tone separation techniques to vary the deformity **21** coverage. Moreover, the pattern of light extracting deformities **21** may be multiple layers or vary in index of refraction.

Print patterns of light extracting deformities **21** may vary in shapes such as dots, squares, diamonds, ellipses, stars, random shapes, and the like, and are desirably 0.006 square inch per deformity/element or less. Also, print patterns that are 60 lines per inch or finer are desirably employed, thus making the deformities or shapes **21** in the print patterns nearly invisible to the human eye in a particular application thereby eliminating the detection of gradient or banding lines that are common to light extracting patterns utilizing larger elements. Additionally, the deformities may vary in shape and/or size along the length and/or width of the panel members. Also, a random placement pattern of the deformities may be utilized throughout the length and/or width of the panel members. The deformities may have shapes or a pattern with no specific angles to reduce moiré or other interference effects. Examples of methods to create these random patterns are printing a pattern of shapes using stochastic print pattern techniques, frequency modulated half tone patterns, or random dot half tones. Moreover, the deformities may be colored in order to effect color correction in the panel members. The color of the deformities may also vary throughout the panel members, for example to provide different colors for the same or different light output areas.

In addition to or in lieu of the patterns of light extracting deformities **21** shown in FIG. **4***a*, other light extracting deformities including prismatic surfaces, depressions or raised surfaces of various shapes using more complex shapes in a mold pattern may be molded, etched, stamped, thermoformed, hot stamped or the like into or on one or more areas of the panel member. FIGS. **4***b* and **4***c* show panel areas **22** on which prismatic surfaces **23** or depressions **24** are formed in the panel areas, whereas FIG. **4***d* shows prismatic or other reflective or refractive surfaces **25** formed on the exterior of the panel area. The prismatic surfaces, depressions or raised surfaces will cause a portion of the light rays contacted thereby to be emitted from the panel member. Also, the angles of the prisms, depressions or other surfaces may be varied to direct the light in different directions to produce a desired light output distribution or effect. Moreover, the reflective or refractive surfaces may have shapes or a pattern with no specific angles to reduce moire or other interference effects.

As best seen in the cross sectional view of FIG. **5**, a back reflector (including trans reflectors) **26** may be attached or positioned against one side of the panel member **14** of FIG. **3** using a suitable adhesive **28** or other method in order to improve light output efficiency of the panel assembly **11** by reflecting the light emitted from that side back through the panel for emission through the opposite side. Additionally, a pattern of light extracting deformities **21**, **23**, **24** and/or **25** may be provided on one or both sides of the panel member in order to change the path of the light so that the internal critical angle is exceeded and a portion of the light is emitted from one or both sides of the panel. Moreover, a transparent film, sheet or plate **27** may be attached or positioned against the side or sides of the panel member from which light is emitted using a suitable adhesive **28** or other method in order to produce a desired effect.

The member **27** may be used to further improve the uniformity of the light output distribution. For example, the member **27** may be a colored film, a diffuser, or a label or display, a portion of which may be a transparent overlay that may be colored and/or have text or an image thereon.

If adhesive **28** is used to adhere the back reflector **26** and/or film **27** to the panel, the adhesive is preferably applied only along the side edges of the panel, and if desired the end edge opposite the light transition areas **12**, but not over the entire surface area or areas of the panel because of the difficulty in consistently applying a uniform coating of adhesive to the panel. Also, the adhesive changes the internal critical angle of the light in a less controllable manner than the air gaps **30** (see FIG. **5**) which are formed between the respective panel surfaces and the back reflector **26** and/or film **27** when only adhered along the peripheral edges. Additionally, longer panel members are achievable when air gaps **30** are used. If adhesive were to be used over the entire surface, the pattern of deformities could be adjusted to account for the additional attenuation in the light caused by the adhesive.

Referring further to FIG. **2**, the panel assembly **5** shown therein also includes molded posts **31** at one or more corners of the panel **7** (four such posts being shown) which may be used to facilitate mounting of the panel assembly and providing structural support for other parts or components, for example, a display panel such as a liquid crystal display panel as desired.

FIG. **6** shows another form of light emitting panel assembly **32** in accordance with this invention including a panel member **33**, one or more light sources **3**, and one or more light output areas **34**. In addition, the panel assembly **32** includes a tray **35** having a cavity or recess **36** in which the panel assembly **32** is received. The tray **35** may act as a back reflector as well as end edge and/or side edge reflectors for the panel **33** and side and/or back reflectors **37** for the light sources **3**. Additionally, one or more secondary reflective or refractive surfaces **38** may be provided on the panel member **33** and/or tray **35** to reflect a portion of the light around one or more corners or curves in a non-rectangular shaped panel member **33**. These secondary reflective/refractive surfaces **38** may be flat, angled, faceted or curved, and may be used to extract a portion of the light away from the panel member in a prede-

termined pattern. FIG. **6** also shows multiple light output areas **34** on the panel member that emit light from one or more light sources **3**.

FIG. **7** is a schematic illustration of still another form of light emitting panel assembly **40** in accordance with this invention including a panel member **41** having one or more light output areas **42** and one or more light transition areas (mixing areas) **43** containing a plurality of light sources **3** at one or both ends of the panel. Each transition area mixes the light from one or more light sources having different colors and/or intensities. In this particular embodiment, each of the light sources **3** desirably employs three colored LEDs (red, blue, green) in each transition mixing area **43** so that the light from the three LEDs can be mixed to produce a desired light output color that will be emitted from the light output area **42**. Alternatively, each light source may be a single LED having multiple colored chips bonded to the lead film. Also, two colored LEDs or a single LED having two colored chips may be used for a particular application. By varying the intensities of the individual respective LEDs, virtually any colored light output or white light distribution can be achieved.

FIG. **8** shows yet another form of light emitting panel assembly **45** in accordance with this invention including a light emitting panel member **46** and a light source **3** in a light transition area **48** integral with one end of the panel member. In this particular embodiment, the panel member **46** is three-dimensionally curved, for example, such that light rays may be emitted in a manner that facilitates aesthetic design of a lighted display.

FIG. **9** schematically shows another form of light emitting panel assembly **50** in accordance with this invention, including a panel member **51** having multiple light output areas **52**, and mounting posts and/or mounting tabs **53**. This particular panel assembly **50** may serve as a structural member to support other parts or components as by providing holes or cavities **54**, **55** in the panel member **51** which allow for the insertion of modular components or other parts into the panel member. Moreover, a separate cavity or recess **56** may be provided in the panel member **51** for receipt of a correspondingly shaped light transition area **57** having one or more light sources **3** embedded, bonded, cast, insert molded, epoxied, or otherwise mounted or positioned therein and a curved reflective or refractive surface **58** on the transition area **57** and/or wall of the cavity or recess **56** to redirect a portion of the light in a predetermined manner. In this way the light transition area **57** and/or panel member may be in the form of a separate insert which facilitates the easy placement of the light source in a modular manner. A reflector **58** may be placed on the reflective or refractive surface of the cavity or recess **56** or insert **57**. Where the reflector **58** is placed on the reflective or refractive surface of the cavity or recess **56**, the cavity or recess may act as a mold permitting transparent material from which the transition area **57** is made to be cast around one or more light sources **3**.

FIGS. **10** and **11** schematically show another form of light emitting panel assembly **60** in accordance with this invention including a panel member **61** having one or more light output areas **62**. In this particular embodiment, an off-axis light transition area **63** is provided that is thicker in cross section than the panel member to permit use of one or more light sources **3** embedded or otherwise mounted in the light transition area that are dimensionally thicker than the panel member. Also, a three-dimensional reflective surface **64** (FIG. **11**) may be provided on the transition area **63**. Moreover, a prism **65** (FIG. **11**) or tapered, rounded, or otherwise shaped end **66** (FIG. **11***a*) may be provided at the end of the panel opposite the light sources **3** to perform the function of an end reflector. The light sources **3** may be oriented at different angles relative to each other and offset to facilitate better mixing of the light rays **67** in the transition area **63** as schematically shown in FIG. **10** and/or to permit a shorter length transition area **63** to be used.

FIGS. **12** and **13** schematically show still another form of light emitting panel assembly **70** in accordance with this invention which includes one or more light transition areas **71** at one or both ends of the panel member **72** each containing a single light source **73**. The transition area or areas **71** shown in FIGS. **12** and **13** collect light with multiple or three-dimensional surfaces and/or collect light in more than one plane. For example each transition area **71** shown in FIGS. **12** and **13** has elliptical and parabolic shape surfaces **74** and **75** in different planes for directing the light rays **76** into the panel member at a desired angle.

Providing one or more transition areas at one or both ends of the panel member of any desired dimension to accommodate one or more light sources, with reflective and/or refractive surfaces on the transition areas for redirecting the light rays into the panel member at relatively low angles allows the light emitting panel member to be made much longer and thinner than would otherwise be possible. For example the panel members of the present invention may be made very thin, i.e., 0.125 inch thick or less.

FIG. **14** schematically illustrates still another form of light emitting panel assembly **80** in accordance with this invention including a light emitting panel **81** and one or more light sources **3** positioned, embedded, potted, bonded or otherwise mounted in a light transition area **82** that is at an angle relative to the panel member **81** to permit more efficient use of space. An angled or curved reflective or refractive surface **83** is provided at the junction of the panel member **81** with the transition area **82** in order to reflect/refract light from the light source **3** into the body of the panel member **81** for emission of light from one or more light emitting areas **84** along the length of the panel member.

FIG. **15** schematically illustrates still another form of light emitting panel assembly **90** in accordance with this invention including a light transition area **91** at one or both ends of a light emitting panel member **92** containing a slot **93** for sliding receipt of an LED or other suitable light source **3**. Preferably the slot **93** extends into the transition area **91** from the back edge **94**, whereby the light source **3** may be slid and/or snapped in place in the slot from the back, thus allowing the transition area to be made shorter and/or thinner. The light source **3** may be provided with wings, tabs or other surfaces **95** for engagement in correspondingly shaped recesses or grooves **96** or the like in the transition area **91** for locating and, if desired, securing the light source in place. Also, the light source **3** may be embedded, potted, bonded or otherwise secured within the slot **93** in the light transition area **91** of the panel member **92**. Light from a secondary light source **97** may be projected through the panel member **92** for indication or some other effect.

The various light emitting panel assemblies disclosed herein may be used for a great many different applications including for example LCD back lighting or lighting in general, decorative and display lighting, automotive lighting, dental lighting, phototherapy or other medical lighting, membrane switch lighting, and sporting goods and apparel lighting or the like. Also the panel assemblies may be made such that the panel members and deformities are transparent without a back reflector. This allows the panel assemblies to be used for example to front light an LCD or other display such that the display is viewed through the transparent panel members.

Although the invention has been shown and described with respect to certain preferred embodiments, it is obvious that equivalent alterations and modifications will occur to others skilled in the art upon the reading and understanding of the specification. The present invention includes all such equivalent alterations and modifications, and is limited only by the scope of the claims.

What is claimed is:

1. A light emitting panel assembly comprising at least one light source, an optical panel member having at least one input edge for receiving light from the at least one light source, the panel member having front and back sides and a greater cross sectional width than thickness, both the front and back sides having a pattern of light extracting deformities that are projections or depressions on or in the sides to cause light to be emitted from the panel member in a predetermined output distribution, where the pattern of light extracting deformities on or in at least one of the sides varies along at least one of the length and width of the panel member and at least some of the light extracting deformities on or in one of the sides are of a different type than the light extracting deformities on or in the other side of the panel member, and at least one film, sheet or substrate overlying at least a portion of one of the sides of the panel member to change the output distribution of the emitted light such that the light will pass through a liquid crystal display with low loss.

2. The assembly of claim **1** wherein the deformities on or in one of the sides are prismatic.

3. The assembly of claim **1** wherein the deformities on or in one of the sides are lenticular.

4. The assembly of claim **1** wherein the deformities on or in one of the sides run the full length or width of the one side.

5. The assembly of claim **1** wherein the deformities on or in one of the sides are quite small in relation to the length and width of the panel member.

6. The assembly of claim **1** wherein the deformities on or in one of the sides have at least one diffuse surface.

7. The assembly of claim **1** wherein the deformities on or in one of the sides are etched dots.

8. The assembly of claim **1** wherein the deformities on or in one of the sides vary randomly.

9. The assembly of claim **1** wherein the panel member is flat.

10. The assembly of claim **1** wherein the panel member is tapered.

11. The assembly of claim **1** wherein the deformities on or in one of the sides vary in at least one of the following characteristics: slope angle, density, orientation, height or depth, and size.

12. The assembly of claim **1** wherein at least one side of the sheet, film or substrate has deformities or optical elements.

13. A light emitting panel assembly comprising at least one light source, an optical panel member having at least one input edge for receiving light from the at least one light source, the panel member having front and back sides and a greater cross sectional width than thickness, both the front and back sides having a pattern of light extracting deformities that are projections or depressions on or in the sides to cause light to be emitted from the panel member in a predetermined output distribution, where the pattern of light extracting deformities on or in at least one of the sides varies along at least one of the length and width of the panel member and at least some of the light extracting deformities on or in one of the sides are of a different type than the light extracting deformities on or in the other side of the panel member, wherein the panel member has a transition region between the at least one input edge and the patterns of light extracting deformities to allow the light from the at least one light source to mix and spread, and at least one side of the transition region contains optical elements for reflecting or refracting light from the at least one light source.

14. The assembly of claim **13** wherein the optical elements are faceted.

15. A light emitting panel assembly comprising at least one light source, an optical panel member having at least one input edge for receiving light from the at least one light source, the panel member having front and back sides and a greater cross sectional width than thickness, at least one of the sides having a pattern of light extracting deformities that are projections or depressions on or in the at least one side to cause light to be emitted from the panel member in a predetermined output distribution, where the pattern of light extracting deformities on or in the at least one side has at least two different types of light extracting deformities and at least one of the types of deformities on or in the at least one side varies along at least one of the length and width of the panel member, and at least one film, sheet or substrate overlying at least a portion of one of the sides of the panel member to change the output distribution of the emitted light such that the light will pass through a liquid crystal display with low loss.

16. The assembly of claim **15** wherein at least one of the types of deformities is prismatic.

17. The assembly of claim **15** wherein at least one of the types of deformities is lenticular.

18. The assembly of claim **15** wherein the deformities on or in the one side run the full length or width of the one side.

19. The assembly of claim **15** wherein at least one of the types of deformities is quite small in relation to the length and width of the panel member.

20. The assembly of claim **15** wherein at least one of the types of deformities has at least one diffuse surface.

21. The assembly of claim **15** wherein at least one of the types of deformities is etched dots.

22. The assembly of claim **15** wherein at least one of the types of deformities varies randomly.

23. The assembly of claim **15** wherein the panel member is flat.

24. The assembly of claim **15** wherein the panel member is tapered.

25. The assembly of claim **15** wherein at least one of the types of deformities varies in at least one of the following characteristics: slope angle, density, orientation, height or depth, and size.

26. The assembly of claim **15** wherein at least one side of the film, sheet or substrate has deformities or optical elements.

27. A light emitting panel assembly comprising at least one light source, an optical panel member having at least one input edge for receiving light from the at least one light source, the panel member having front and back sides and a greater cross sectional width than thickness, at least one of the sides having a pattern of light extracting deformities that are projections or depressions on or in the at least one side to cause light to be emitted from the panel member in a predetermined output distribution, where the pattern of light extracting deformities on or in the at least one side has at least two different types of light extracting deformities and at least one of the types of deformities on or in the at least one side varies alone at least one of the length and width of the panel member, wherein the panel member has a transition region between the at least one input edge and the patterns of light extracting deformities to allow the light from the at least one light source to mix and spread, and at least one side of the

transition region contains optical elements for reflecting or refracting light from the at least one light source.

28. The assembly of claim **27** wherein the optical elements are faceted.

29. A light emitting panel assembly comprising at least one light source, an optical panel member having at least one input edge for receiving light from the at least one light source, the panel member having front and back sides and a greater cross sectional width than thickness, both the front and back sides having a pattern of light extracting deformities that are projections or depressions on or in the sides to cause light to be emitted from the panel member in a predetermined output distribution, where the pattern of light extracting deformities on or in at least one of the sides varies along at least one of the length and width of the panel member and at least some of the light extracting deformities on or in one of the sides vary in a different way or manner than the light extracting deformities on or in the other side of the panel member, and at least one film, sheet or substrate overlying at least a portion of one of the sides of the panel member to change the output distribution of the emitted light such that the light will pass through a liquid crystal display with low loss.

30. The assembly of claim **29** wherein at least some of the deformities on or in at least one side vary in density.

31. The assembly of claim **29** wherein at least some of the deformities on or in at least one side vary in slope angle relative to one another.

32. The assembly of claim **29** wherein at least some of the deformities on or in at least one side vary in position.

33. The assembly of claim **29** wherein at least some of the deformities on or in at least one side vary in angle of orientation relative to one another.

34. The assembly of claim **29** wherein at least some of the deformities on or in at least one side vary in height or depth.

35. The assembly of claim **29** wherein at least some of the deformities on or in at least one side vary in size.

36. The assembly of claim **29** wherein at least some of the deformities on or in at least one side do not vary.

37. The assembly of claim **29** wherein at least some of the deformities on or in at least one side vary randomly.

38. The assembly of claim **29** wherein at least some of the deformities are prismatic.

39. The assembly of claim **29** wherein at least some of the deformities are lenticular.

40. The assembly of claim **29** wherein the deformities on or in one of the sides run the full length or width of the one side.

41. The assembly of claim **29** wherein at least some of the deformities are quite small in relation to the length and width of the panel member.

42. The assembly of claim **29** wherein at least some of the deformities have at least one diffuse surface.

43. The assembly of claim **29** wherein at least some of the deformities are etched dots.

44. The assembly of claim **29** wherein the panel member is flat.

45. The assembly of claim **29** wherein the panel member is tapered.

46. The assembly of claim **29** wherein at least one side of the sheet, film or substrate has deformities or optical elements.

47. A light emitting panel assembly comprising at least one light source, an optical panel member having at least one input edge for receiving light from the at least one light source, the panel member having front and back sides and a greater cross sectional width than thickness, both the front and back sides having a pattern of light extracting deformities that are projections or depressions on or in the sides to cause light to be emitted from the panel member in a predetermined output distribution, where the pattern of light extracting deformities on or in at least one of the sides varies along at least one of the length and width of the panel member and at least some of the light extracting deformities on or in one of the sides vary in a different way or manner than the light extracting deformities on or in the other side of the panel member, wherein the panel member has a transition region between the at least one input edge and the patterns of light extracting deformities to allow the light from the at least one light source to mix and spread, and at least one side of the transition region contains optical elements for reflecting or refracting light from the at least one light source.

48. The assembly of claim **47** wherein the optical elements are faceted.

* * * * *

EXHIBIT C

US007914196B2

(12) **United States Patent**
Parker et al.

(10) **Patent No.: US 7,914,196 B2**
(45) **Date of Patent: *Mar. 29, 2011**

(54) **LIGHT REDIRECTING FILM SYSTEMS HAVING PATTERN OF VARIABLE OPTICAL ELEMENTS**

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(73) Assignee: **Rambus International Ltd.** (KY)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 306 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **12/054,680**

(22) Filed: **Mar. 25, 2008**

(65) **Prior Publication Data**

US 2008/0239755 A1 Oct. 2, 2008

Related U.S. Application Data

(60) Division of application No. 11/484,063, filed on Jul. 11, 2006, now Pat. No. 7,364,342, which is a division of application No. 10/729,113, filed on Dec. 5, 2003, now Pat. No. 7,090,389, which is a division of application No. 09/909,318, filed on Jul. 19, 2001, now Pat. No. 6,752,505, and a continuation-in-part of application No. 09/256,275, filed on Feb. 23, 1999, now Pat. No. 6,712,481.

(51) **Int. Cl.**
F21V 7/04 (2006.01)

(52) **U.S. Cl.** **362/618**; 362/627; 362/624; 349/65; 385/131

(58) **Field of Classification Search** 362/615, 362/618, 619, 620, 624, 625, 626, 606, 608, 362/627; 385/131; 349/65, 69, 70
See application file for complete search history.

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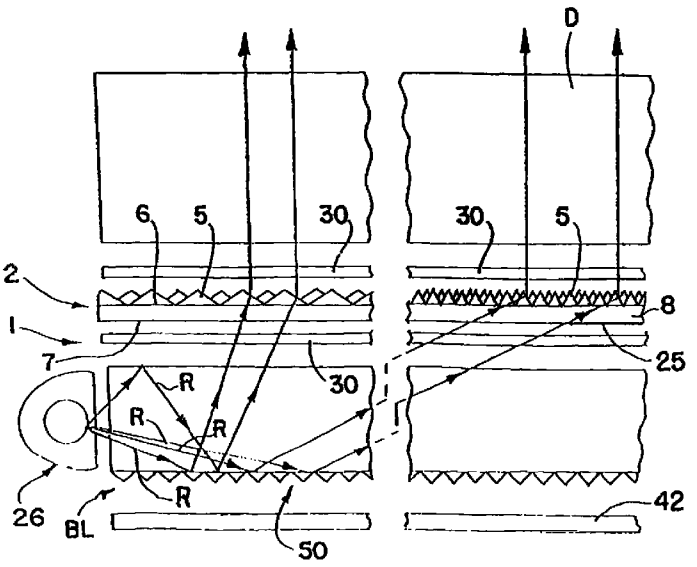
Primary Examiner — Ismael Negron
(74) *Attorney, Agent, or Firm* — Renner, Otto, Boisselle & Sklar, LLP

(57) **ABSTRACT**

Light redirecting film systems comprise a backlight having deformities that cause a majority of the light entering the input edge of the backlight to be emitted from a light output surface of the backlight. In close proximity to the light output surface is a light redirecting film that has a pattern of individual optical elements of well-defined shape to redistribute the light emitted by the light output surface toward a direction normal to the film.

25 Claims, 18 Drawing Sheets



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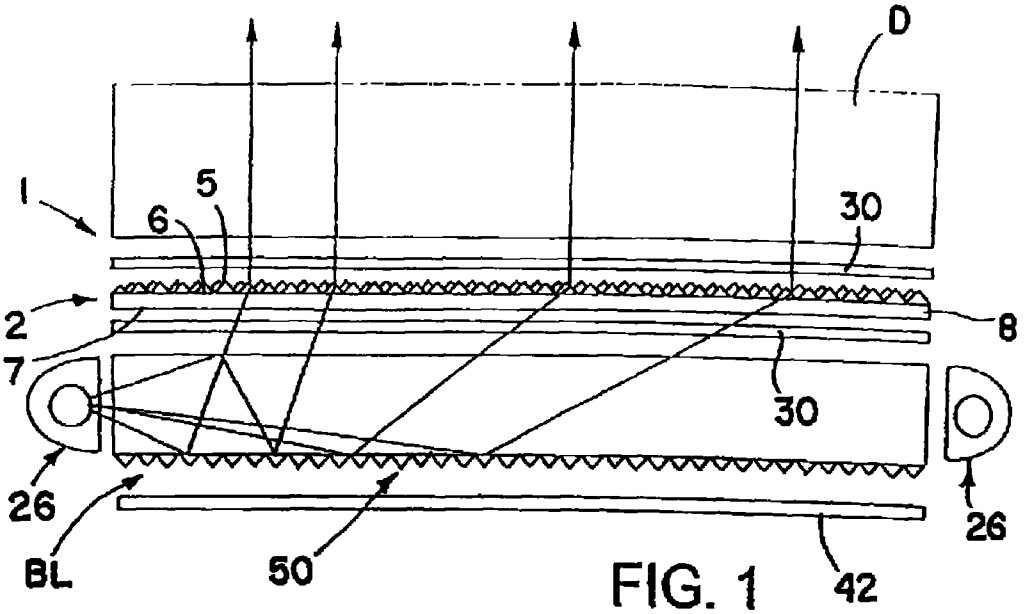

FIG. 1

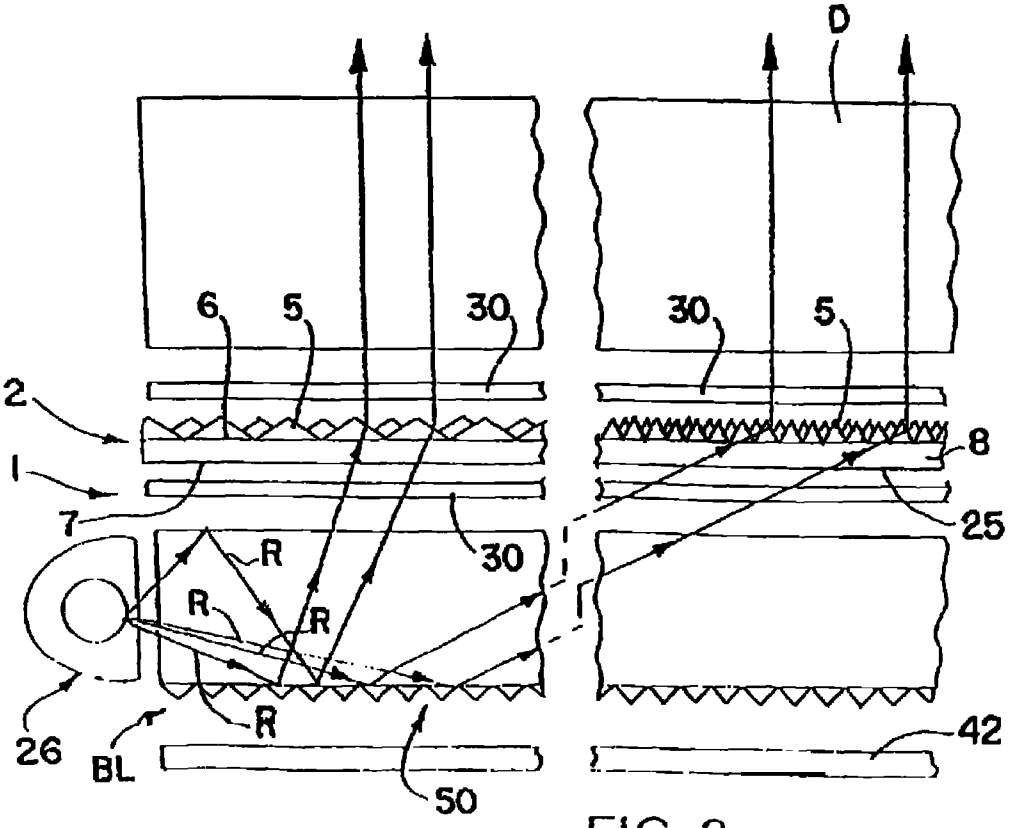

FIG. 2

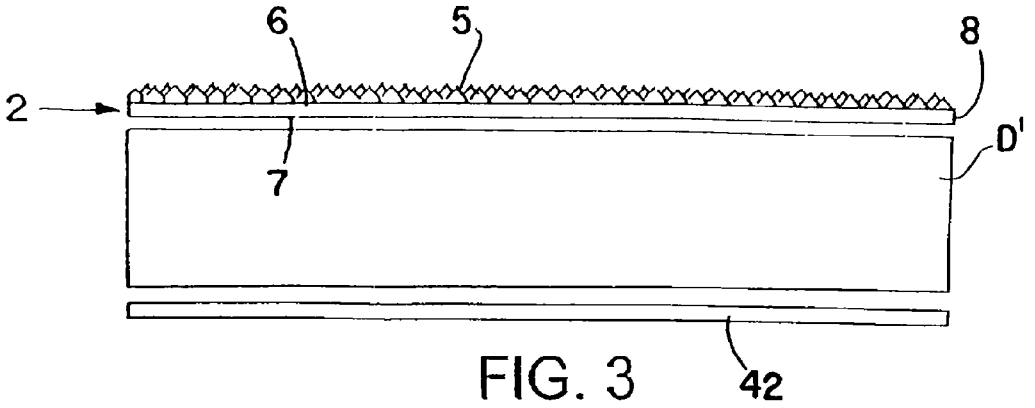

FIG. 3

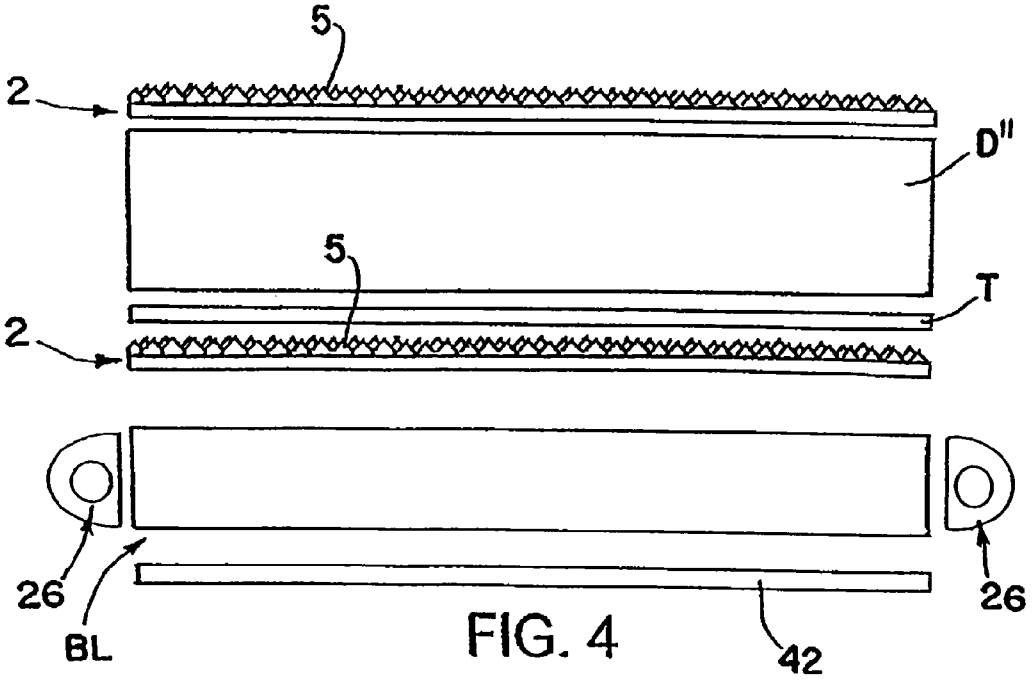

FIG. 4

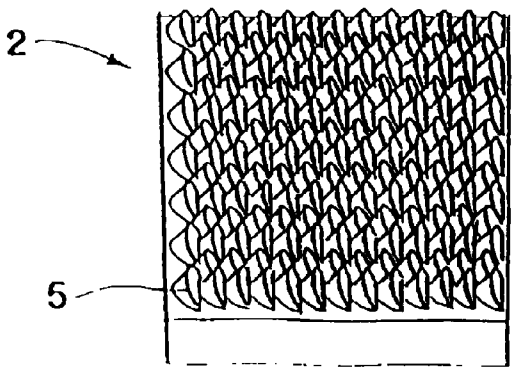

FIG. 5

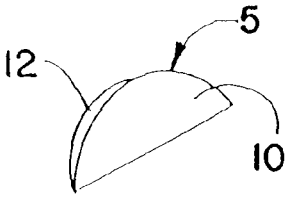

FIG. 5a

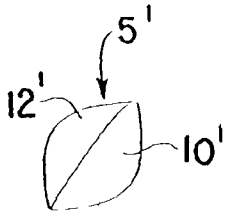

FIG. 5b

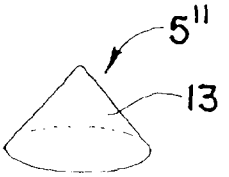

FIG. 5c

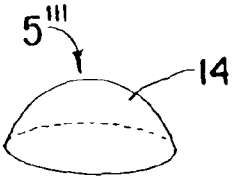

FIG.5d

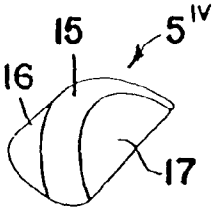

FIG. 5e

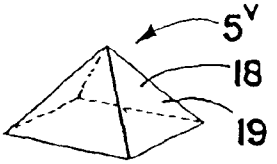

FIG.5f

FIG. 5g

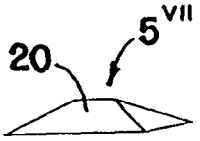

FIG. 5h

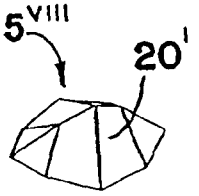

FIG.5i

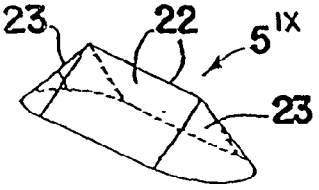

FIG.5j

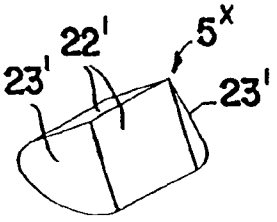

FIG. 5k

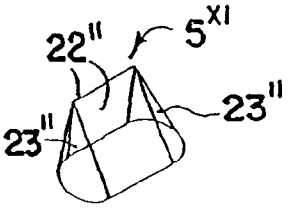

FIG.5l

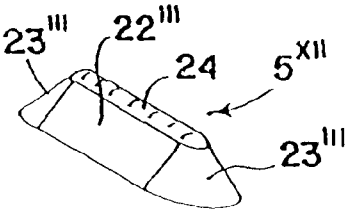

FIG.5m

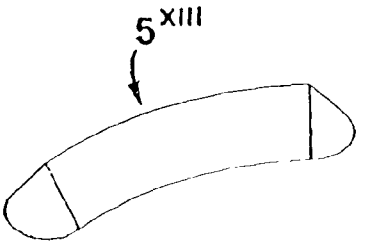

FIG.5n

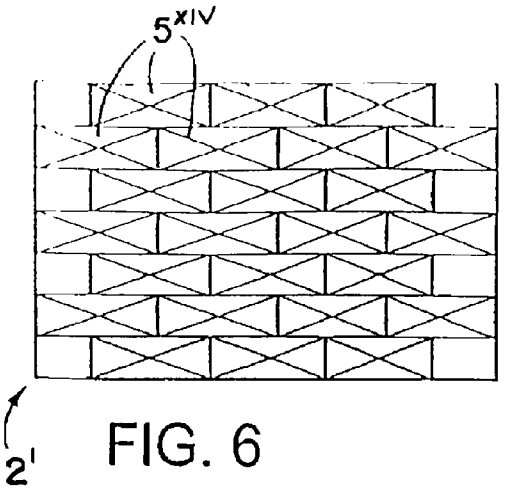

FIG. 6

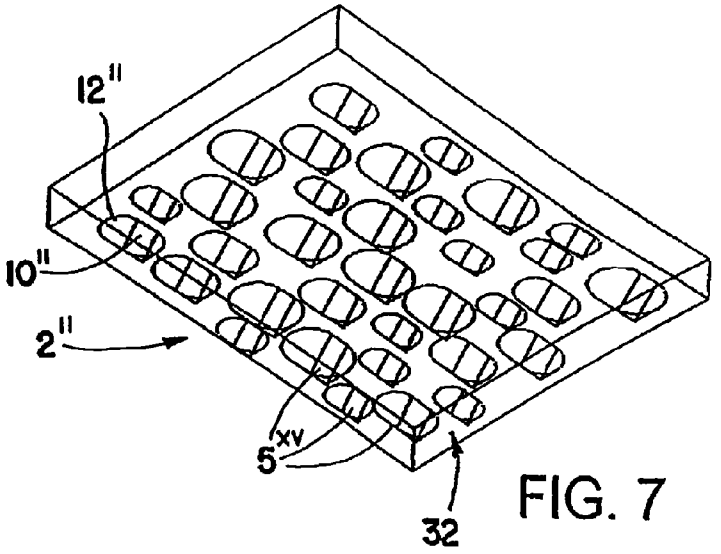

FIG. 7

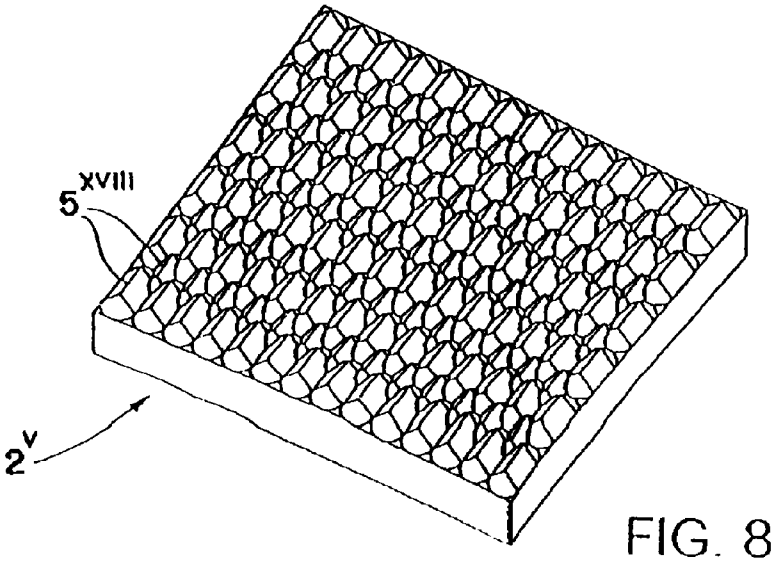

FIG. 8

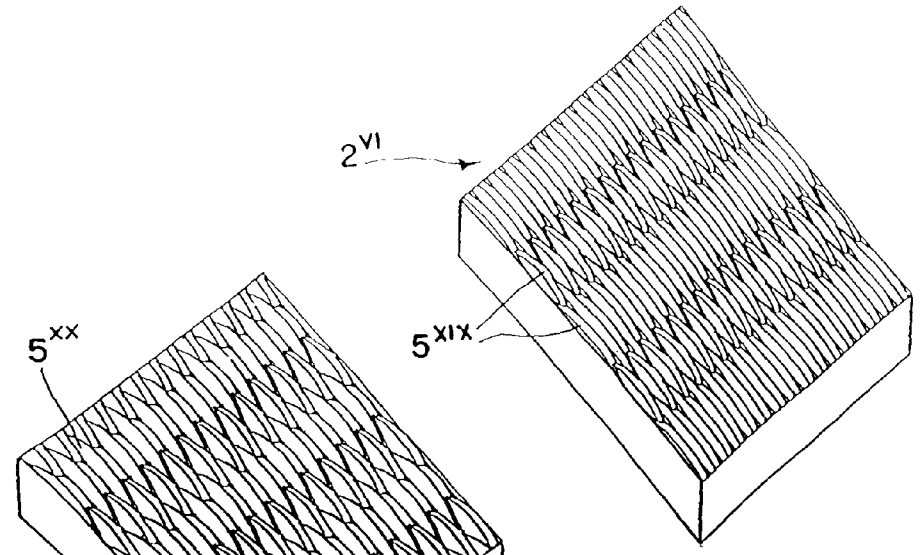

FIG.9

FIG. 10

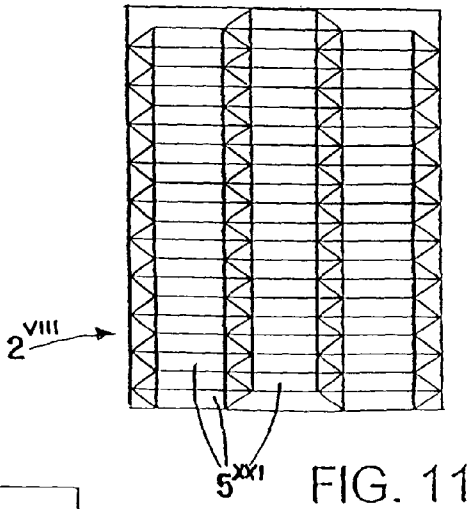

FIG. 11

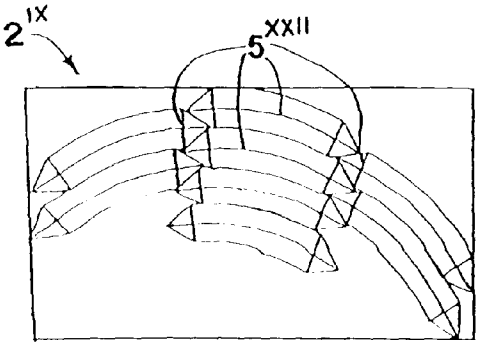

FIG. 12

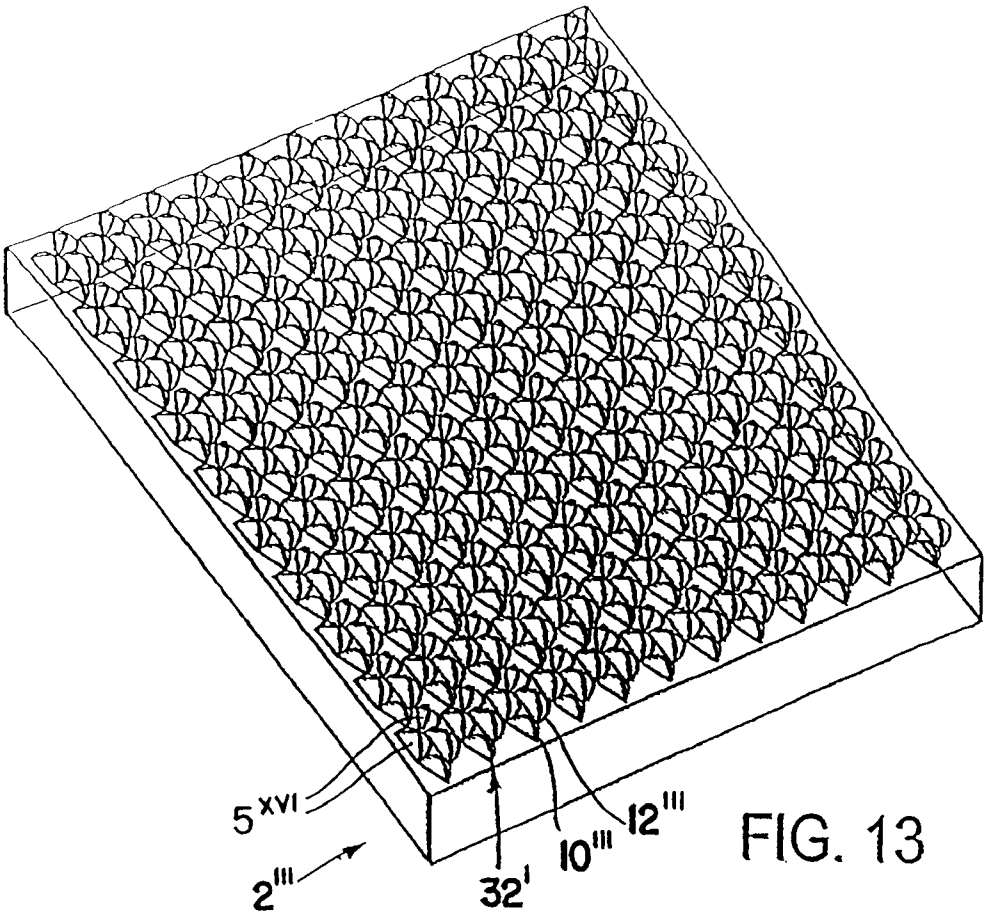

FIG. 13

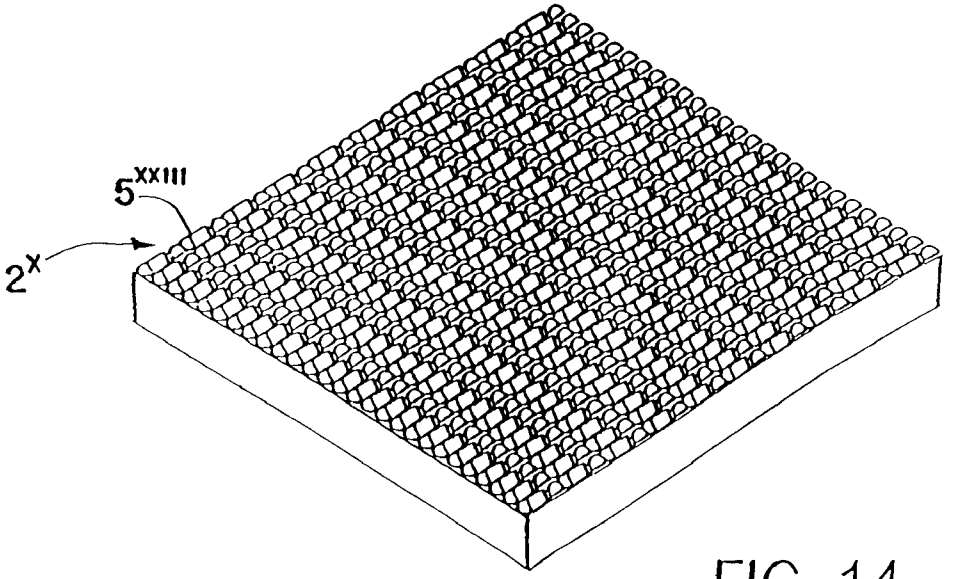

FIG. 14

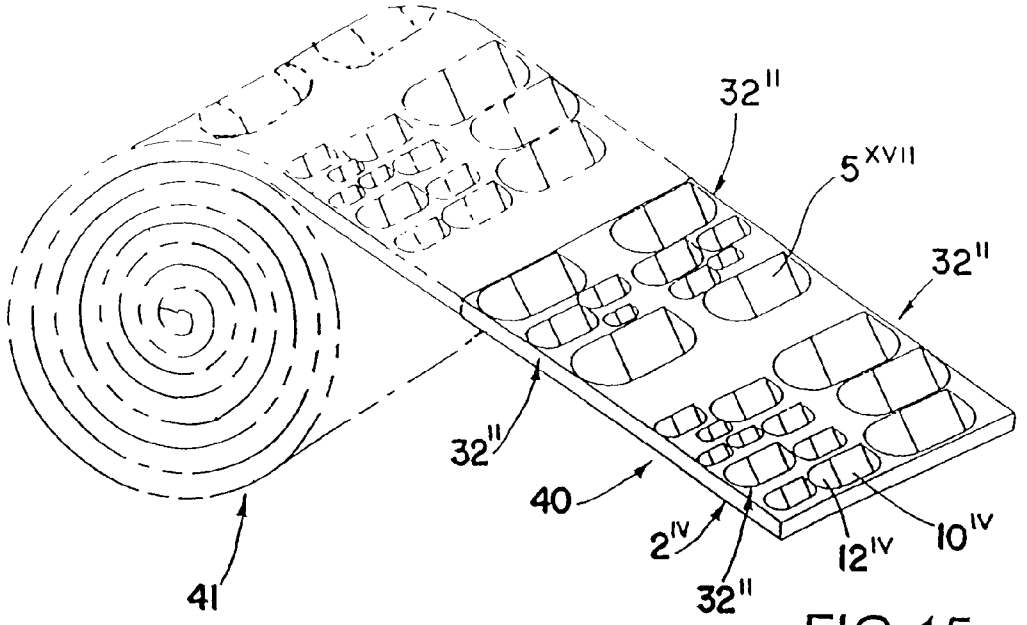

FIG.15

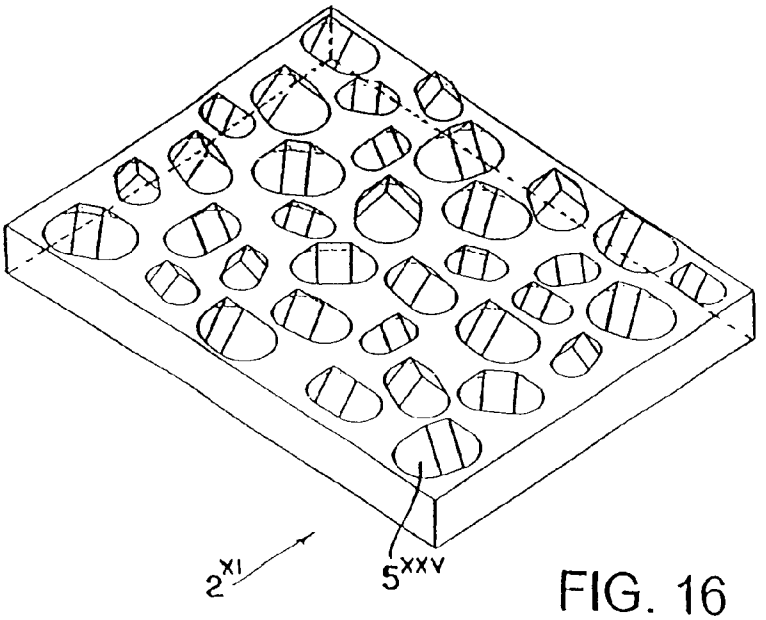

FIG. 16

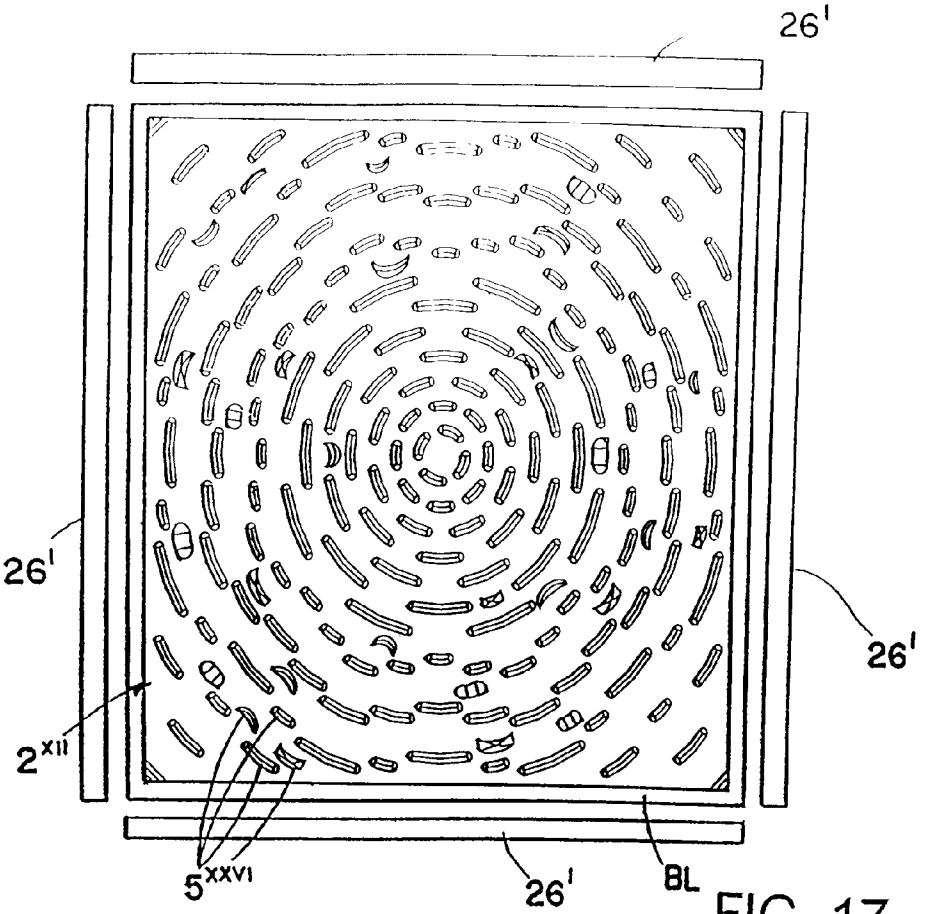

FIG. 17

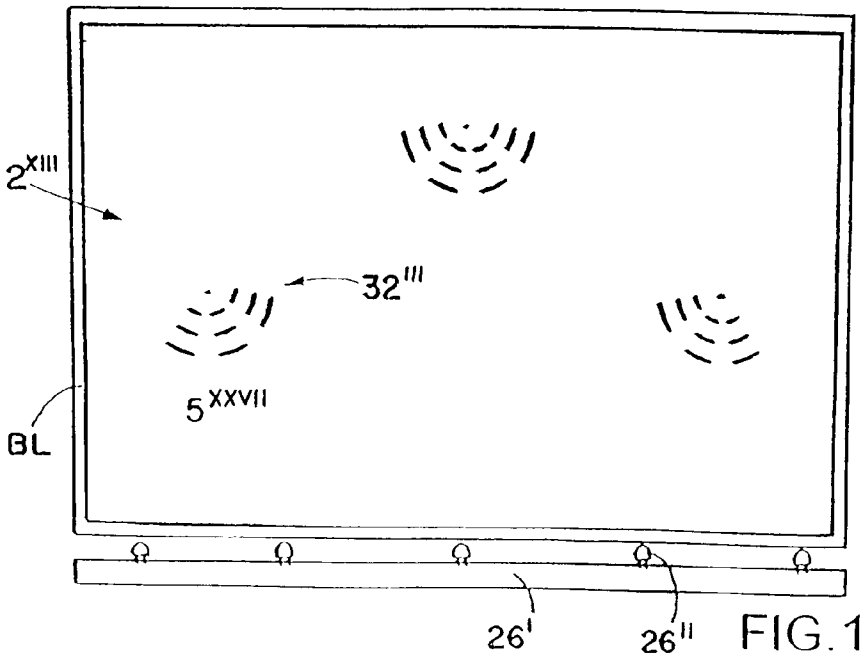

FIG. 18

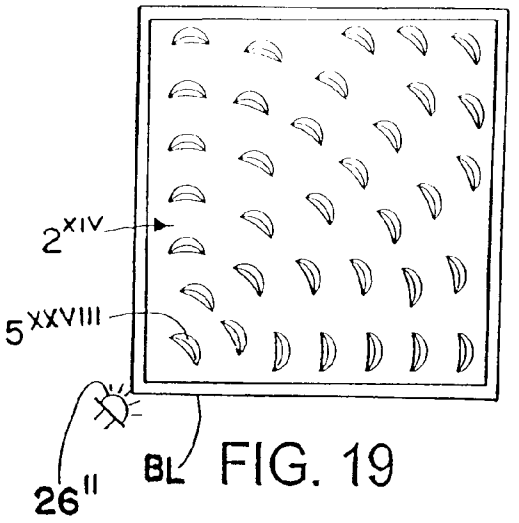

FIG. 19

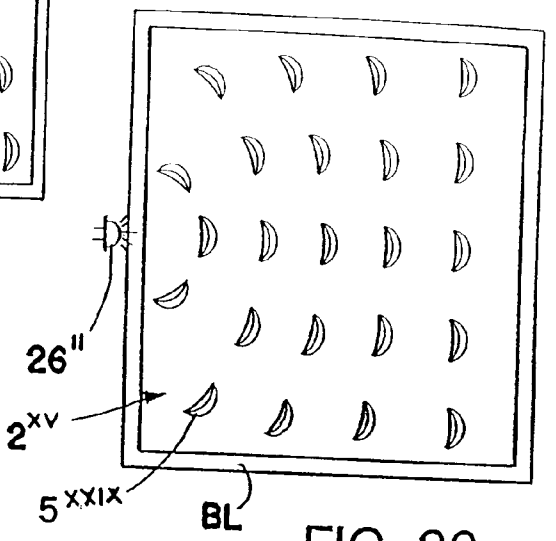

FIG. 20

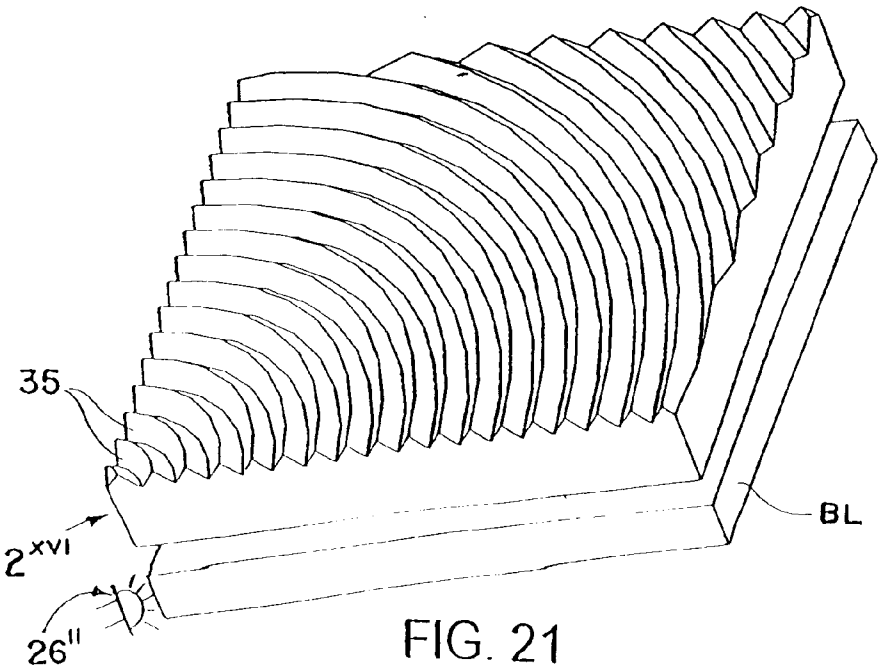

FIG. 21

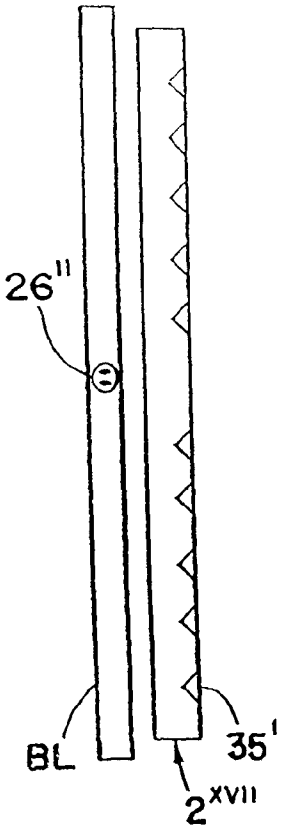

FIG. 23

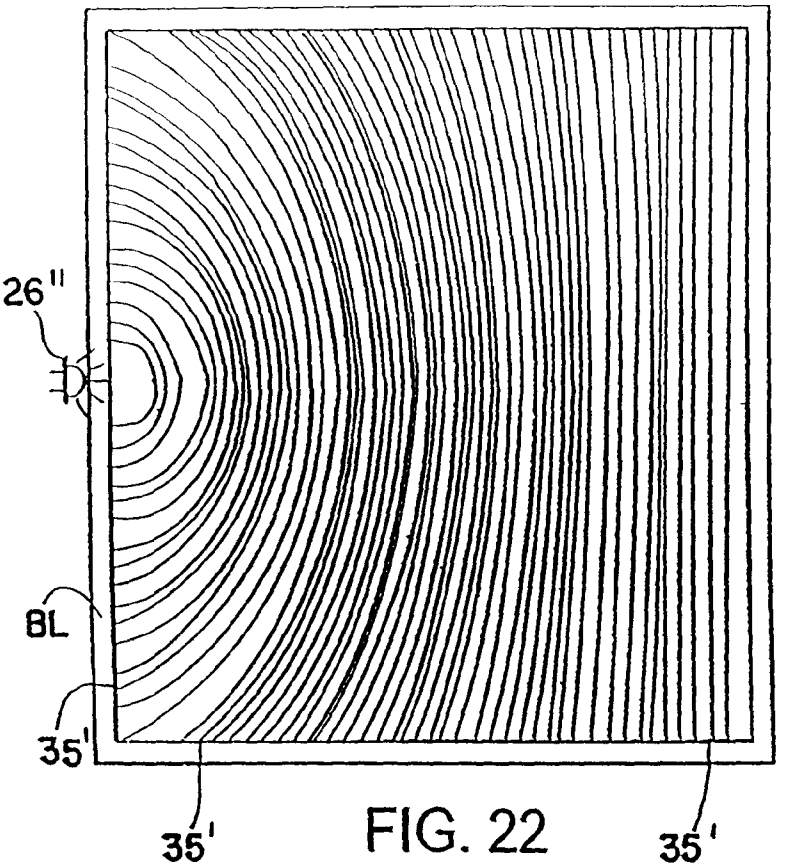

FIG. 22

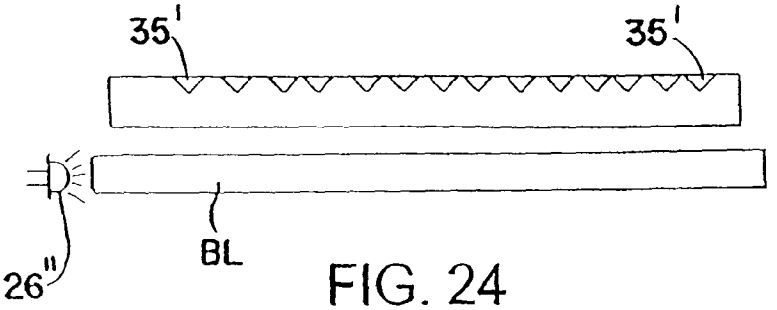

FIG. 24

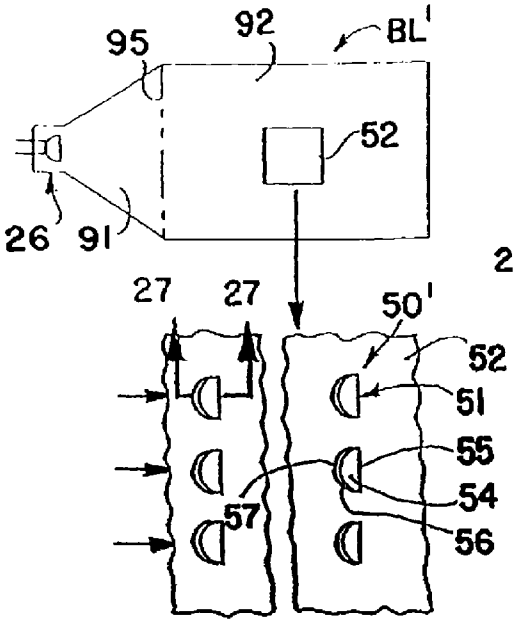

FIG. 25

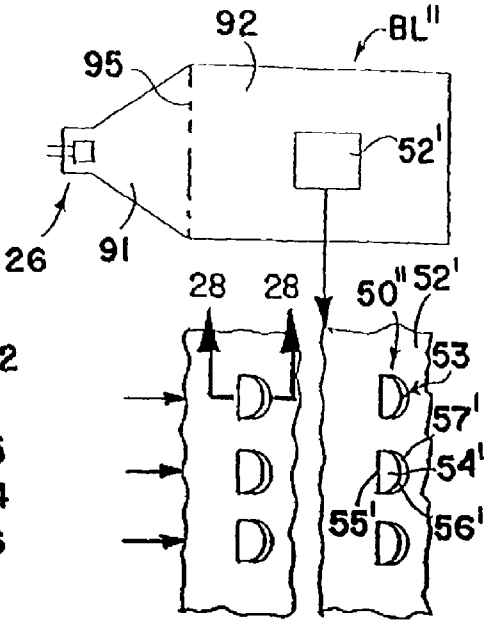

FIG. 26

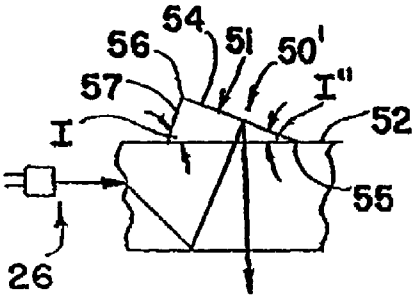

FIG. 27

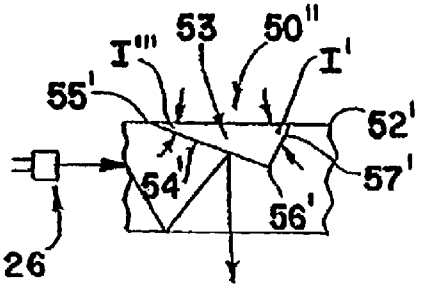

FIG. 28

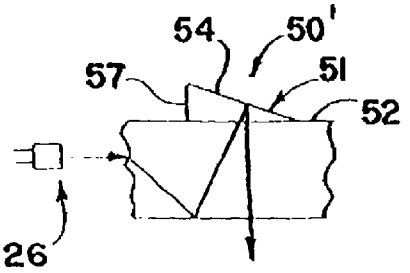

FIG. 29

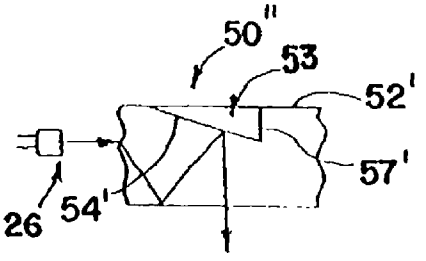

FIG. 30

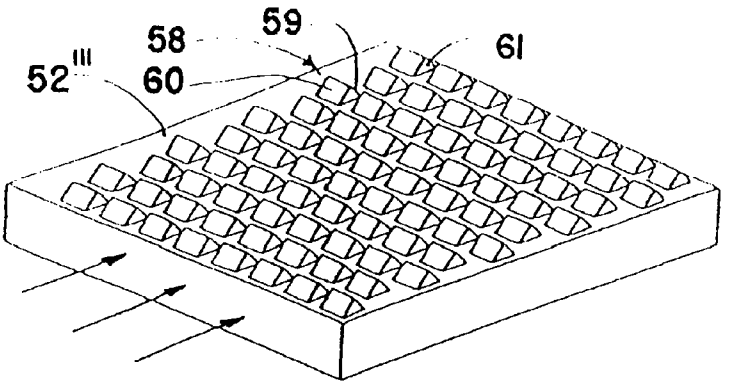

FIG. 31

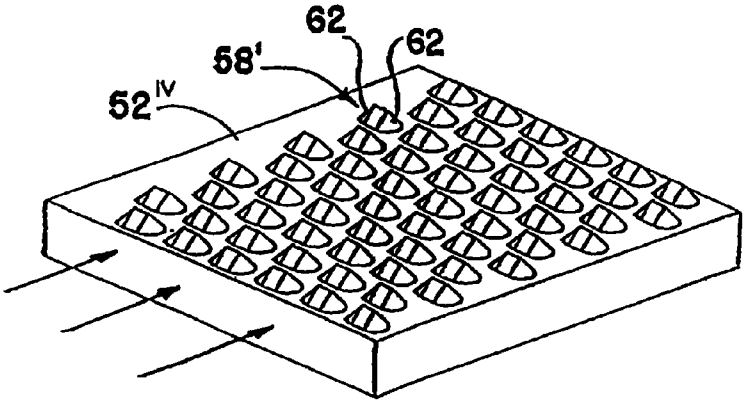

FIG. 32

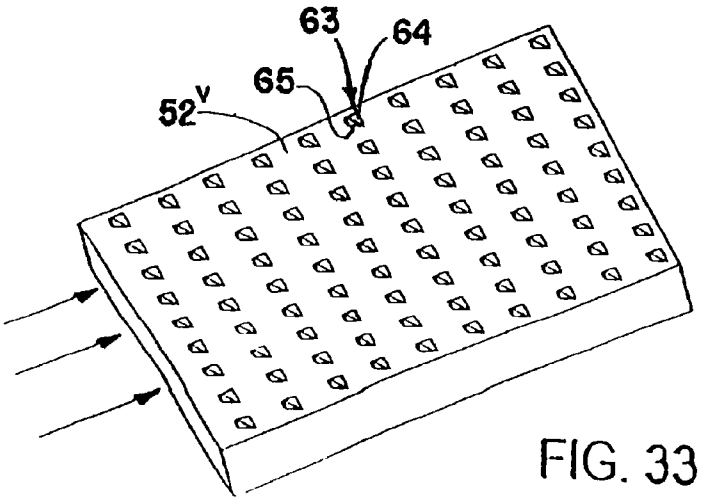

FIG. 33

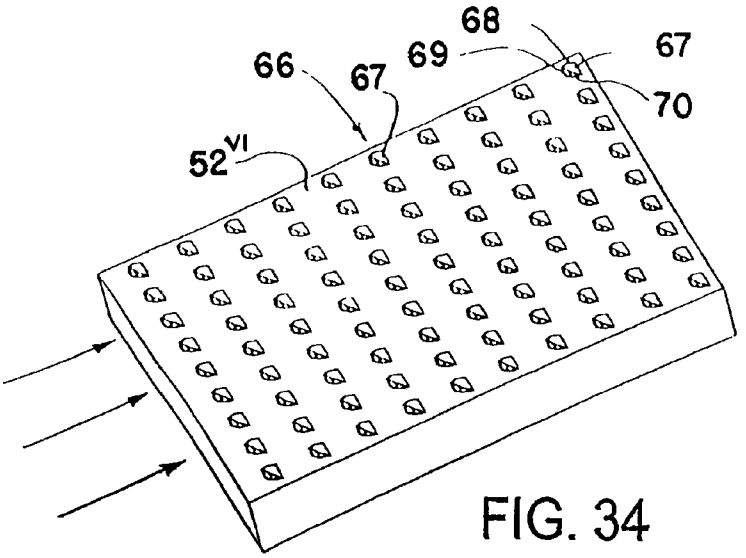

FIG. 34

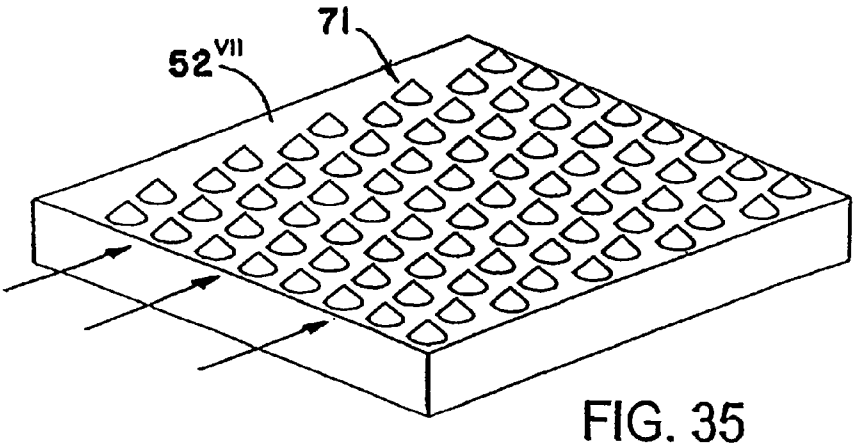

FIG. 35

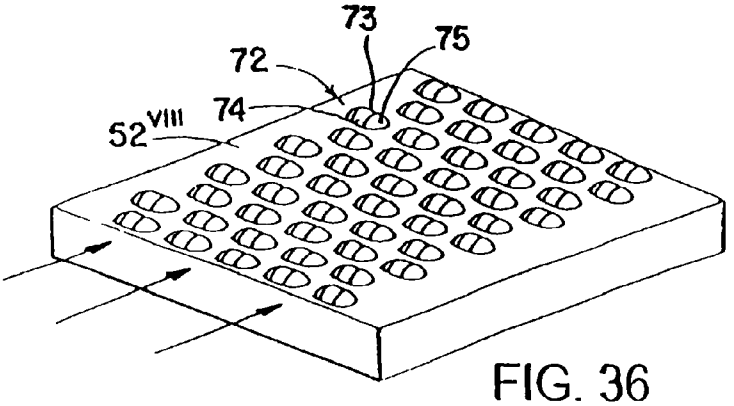

FIG. 36

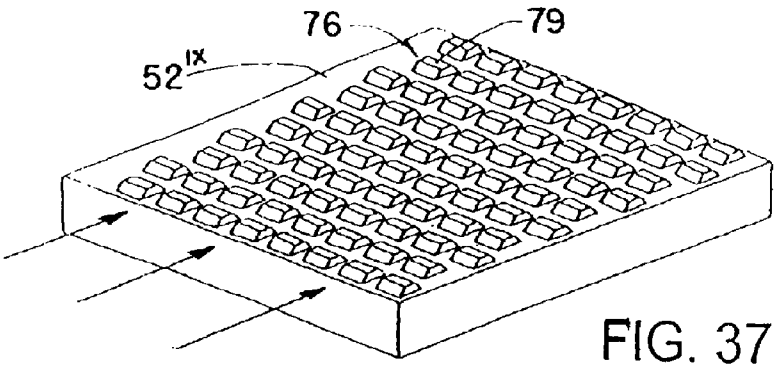

FIG. 37

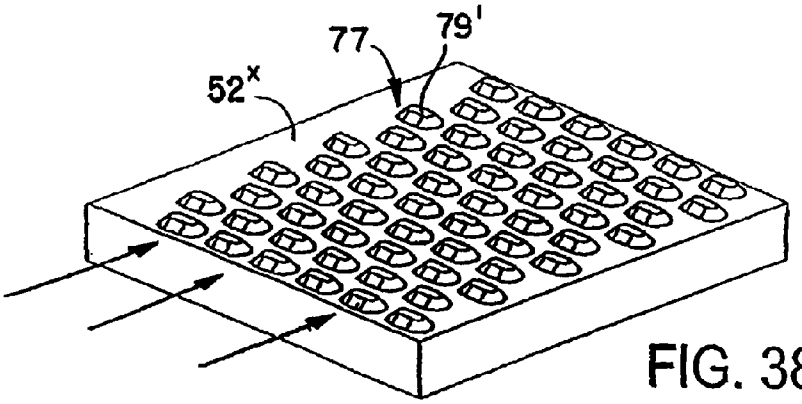

FIG. 38

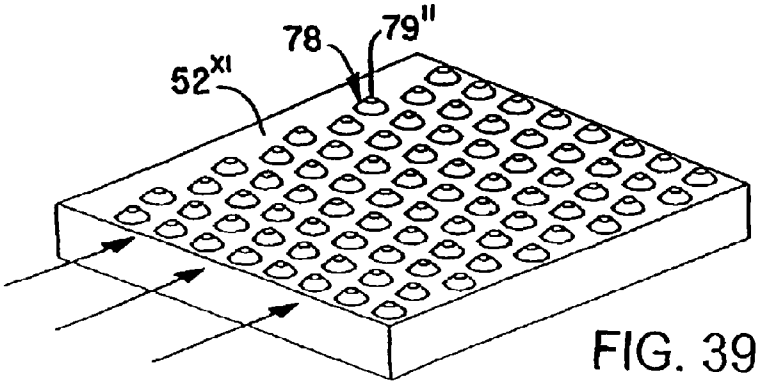

FIG. 39

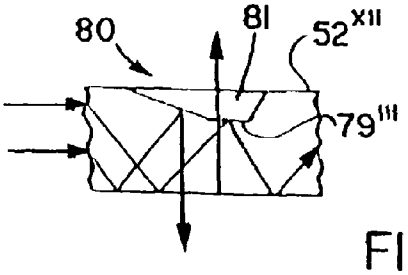

FIG. 40

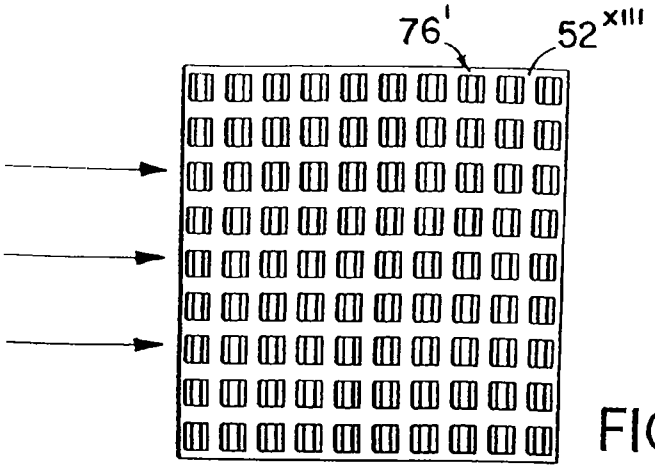

FIG. 41

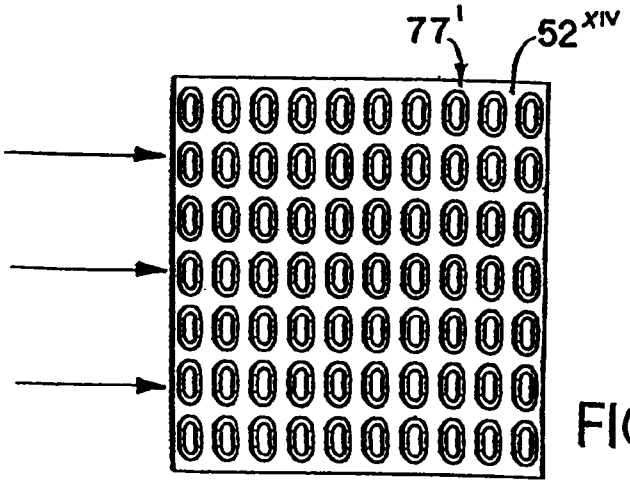

FIG. 42

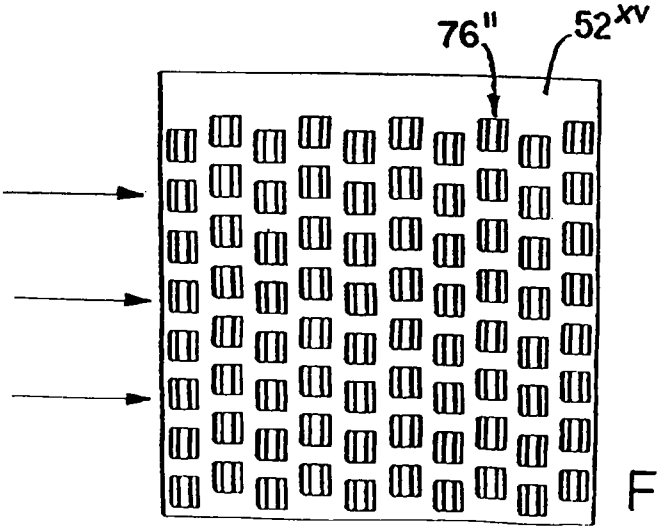

FIG. 43

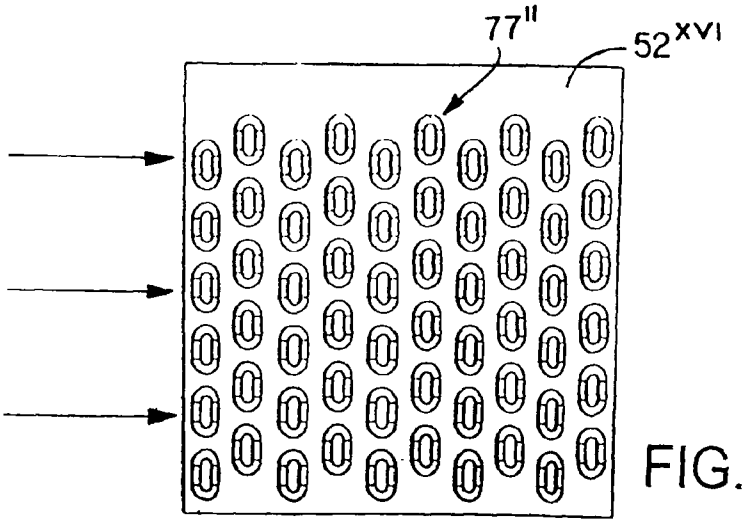

FIG. 44

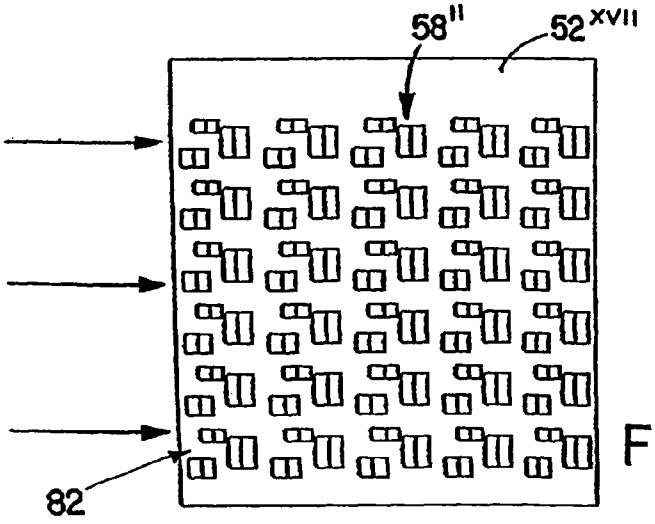

FIG. 45

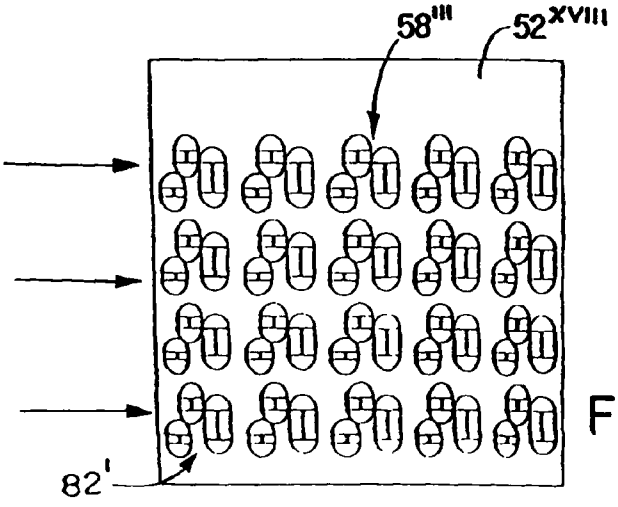

FIG. 46

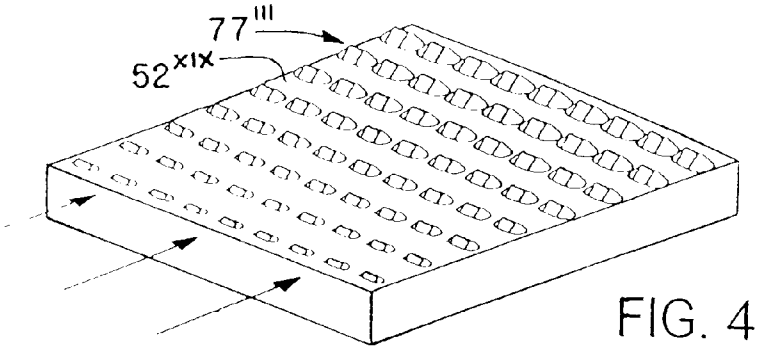

FIG. 47

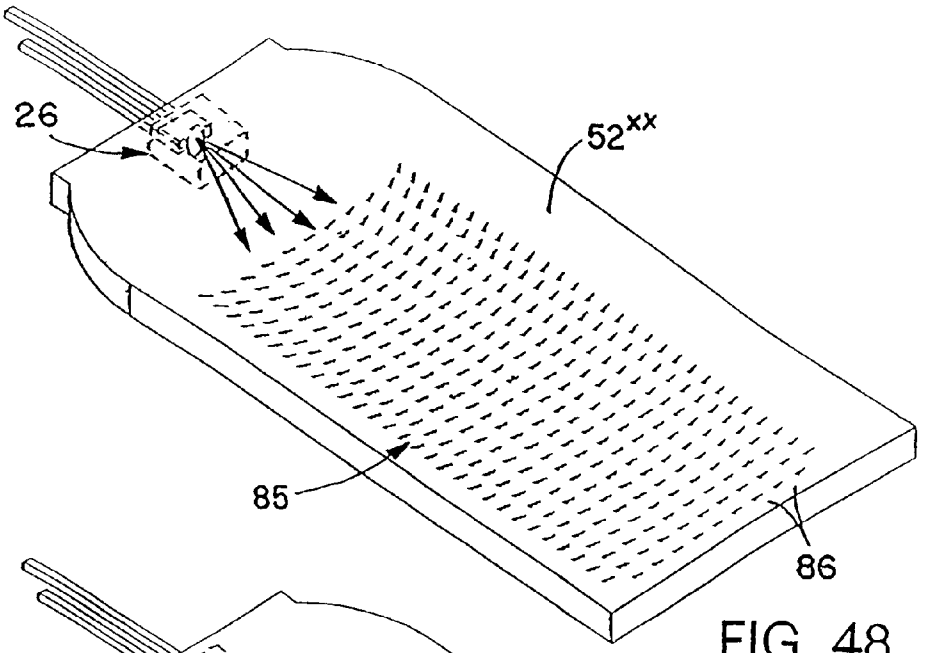

FIG. 48

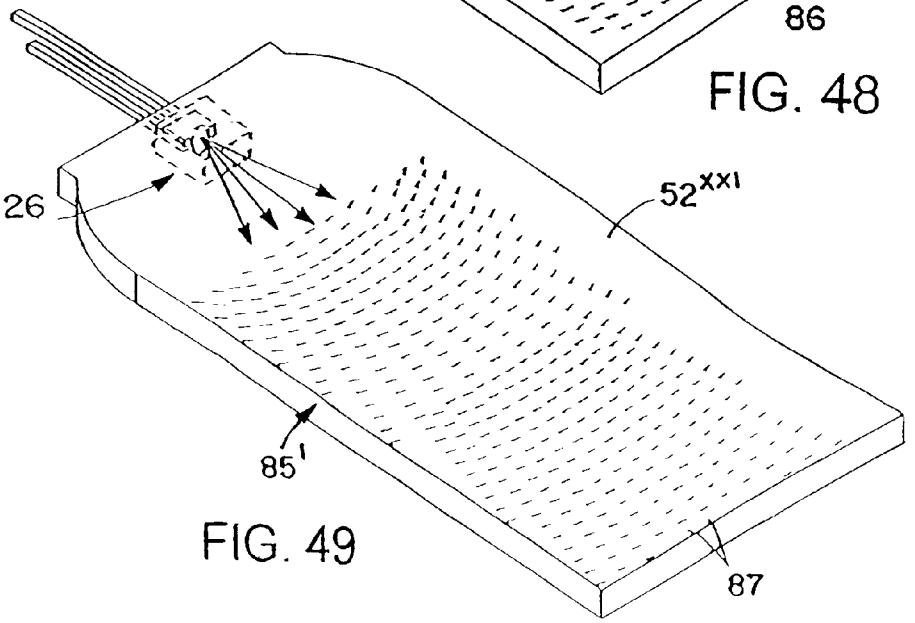

FIG. 49

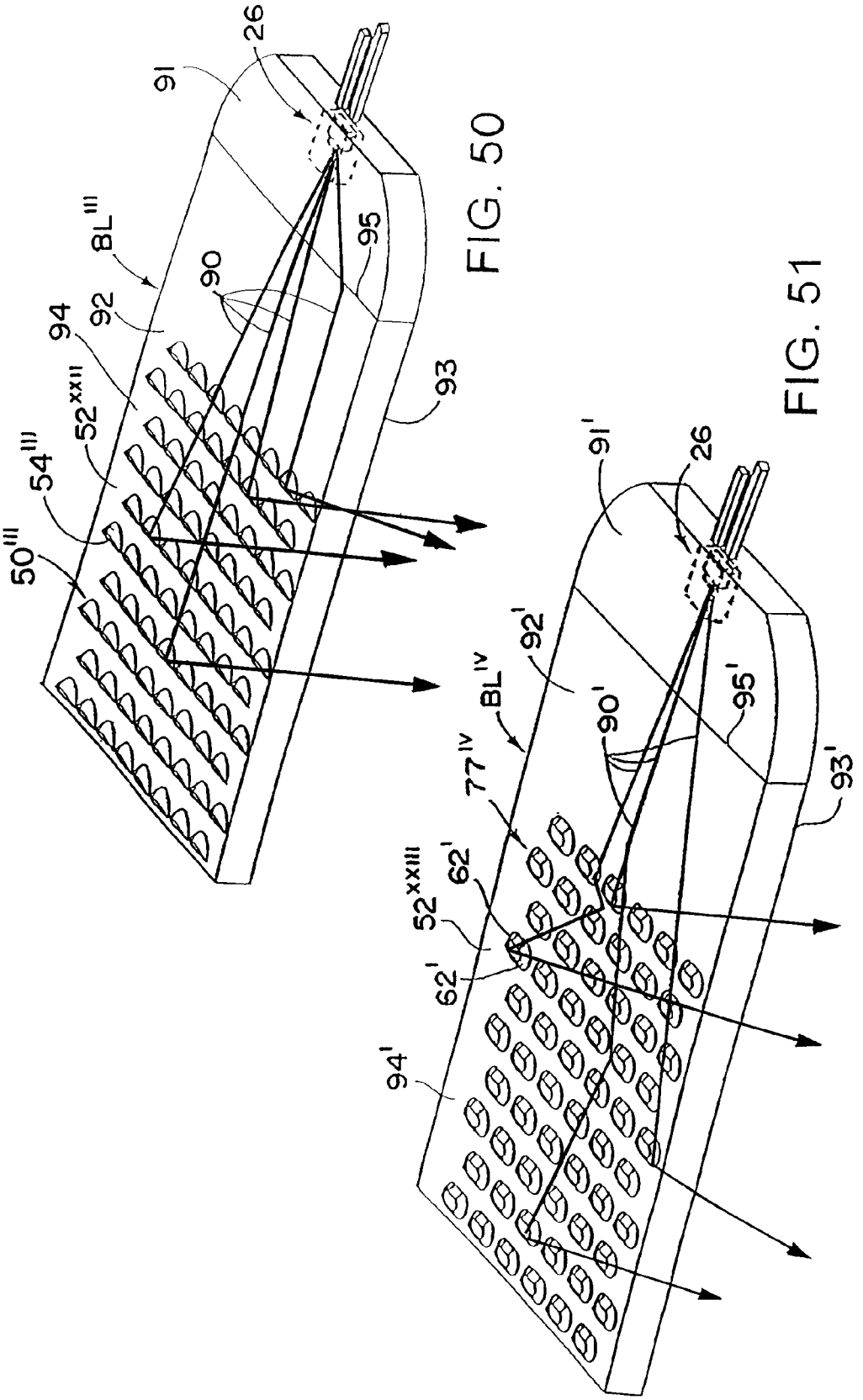
26
91
BL III
90
95
94
92
52 XXII
54 III
50 III
93
91'
26
92'
BL IV
90'
95'
77 IV
93'
62'
52 XXIII
62'
94'

FIG. 50

FIG. 51

LIGHT REDIRECTING FILM SYSTEMS HAVING PATTERN OF VARIABLE OPTICAL ELEMENTS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a division of U.S. patent application Ser. No. 11/484,063, filed Jul. 11, 2006, which is a division of U.S. patent application Ser. No. 10/729,113, filed Dec. 5, 2003, now U.S. Pat. No. 7,090,389, which is a division of U.S. patent application Ser. No. 09/909,318, filed Jul. 19, 2001, now U.S. Pat. No. 6,752,505, which is a continuation-in-part of U.S. patent application Ser. No. 09/256,275, filed Feb. 23, 1999, now U.S. Pat. No. 6,712,481, the entire disclosures of which are incorporated herein by reference.

FIELD OF THE INVENTION

This invention relates to light redirecting films and film systems for redirecting light from a light source toward a direction normal to the plane of the films.

BACKGROUND OF THE INVENTION

Light redirecting films are thin transparent or translucent optical films or substrates that redistribute the light passing through the films such that the distribution of the light exiting the films is directed more normal to the surface of the films. Heretofore, light redirecting films were provided with prismatic grooves, lenticular grooves, or pyramids on the light exit surface of the films which changed the angle of the film/air interface for light rays exiting the films and caused the components of the incident light distribution traveling in a plane perpendicular to the refracting surfaces of the grooves to be redistributed in a direction more normal to the surface of the films. Such light redirecting films are used, for example, with liquid crystal displays, used in laptop computers, word processors, avionic displays, cell phones, PDAs and the like to make the displays brighter.

The light entrance surface of the films usually has a transparent or matte finish depending on the visual appearance desired. A matte finish produces a softer image but is not as bright due to the additional scattering and resultant light loss caused by the matte or diffuse surface.

Heretofore, most applications used two grooved film layers rotated relative to each other such that the grooves in the respective film layers are at 90 degrees relative to each other. The reason for this is that a grooved light redirecting film will only redistribute, towards the direction normal to the film surface, the components of the incident light distribution traveling in a plane perpendicular to the refracting surfaces of the grooves. Therefore, to redirect light toward the normal of the film surface in two dimensions, two grooved film layers rotated 90 degrees with respect to each other are needed, one film layer to redirect light traveling in a plane perpendicular to the direction of its grooves and the other film layer to redirect light traveling in a plane perpendicular to the direction of its grooves.

Attempts have been made in the past to create a single layer light redirecting film that will redirect components of the incident light distribution traveling along two different axes 90 degrees to each other. One known way of accomplishing this is to provide a single layer film with two sets of grooves extending perpendicular to each other resulting in a pyramid structure which redirects light traveling in both such directions. However, such a film produces a much lower brightness than two film layers each with a single groove configuration rotated 90 degrees with respect to each other because the area that is removed from the first set of grooves by the second set of grooves in a single layer film reduces the surface area available to redirect light substantially by 50% in each direction of travel.

In addition, heretofore, the grooves of light redirecting films have been constructed so that all of the grooves meet the surface of the films at the same angle, mostly 45 degrees. This design assumes a constant, diffuse angular distribution of light from the light source, such as a lambertian source, a backlighting panel using a printing or etching technology to extract light, or a backlighting panel behind heavy diffusers. A light redirecting film where all of the light redirecting surfaces meet the film at the same angle is not optimized for a light source that has a nonuniform directional component to its light emission at different areas above the source. For example, the average angle about which a modern high efficiency edge lit backlight, using grooves or micro-optical surfaces to extract light, changes at different distances from the light source, requiring a different angle between the light redirecting surfaces and the plane of the film to optimally redirect light toward the normal of the film.

There is thus a need for a light redirecting film that can produce a softer image while eliminating the decrease in brightness associated with a matte or diffuse finish on the light input side of the film. Also, there is a need for a single layer of film which can redirect a portion of the light traveling in a plane parallel to the refracting surfaces in a grooved film, that would be brighter than a single layer of film using prismatic or lenticular grooves. In addition, there is a need for a light redirecting film that can compensate for the different angular distributions of light that may exist for a particular light source at different positions above the source, such as backlights used to illuminate liquid crystal displays. Also, there is a need for a light redirecting film system in which the film is matched or tuned to the light output distribution of a backlight or other light source to reorient or redirect more of the incident light from the backlight within a desired viewing angle.

SUMMARY OF THE INVENTION

The present invention relates to light redirecting films and light redirecting film systems that redistribute more of the light emitted by a backlight or other light source toward a direction more normal to the plane of the films, and to light redirecting films that produce a softer image without the brightness decrease associated with films that have a matte or diffuse finish on the light entrance surface of the films, for increased effectiveness.

The light exit surface of the films has a pattern of discrete individual optical elements of well defined shape for refracting the incident light distribution such that the distribution of light exiting the films is in a direction more normal to the surface of the films. These individual optical elements may be formed by depressions in or projections on the exit surface of the films, and include one or more sloping surfaces for refracting the incident light toward a direction normal to the exit surface. These sloping surfaces may for example include a combination of planar and curved surfaces that redirect the light within a desired viewing angle. Also, the curvature of the surfaces, or the ratio of the curved area to the planar area of the individual optical elements as well as the perimeter shapes of the curved and planar surfaces may be varied to tailor the light output distribution of the films, to customize the viewing angle of the display device used in conjunction with the films.

In addition, the curvature of the surfaces, or the ratio of the curved area to the planar area of the individual optical elements may be varied to redirect more or less light that is traveling in a plane that would be parallel to the grooves of a prismatic or lenticular grooved film. Also the size and population of the individual optical elements, as well as the curvature of the surfaces of the individual optical elements may be chosen to produce a more or less diffuse output or to randomize the input light distribution from the light source to produce a softer more diffuse light output distribution while maintaining the output distribution within a specified angular region about the direction normal to the films.

The light entrance surface of the films may have an optical coating such as an antireflective coating, a reflective polarizer, a retardation coating or a polarizer. Also a matte or diffuse texture may be provided on the light entrance surface depending on the visual appearance desired. A matte finish produces a softer image but is not as bright.

The individual optical elements on the exit surface of the films may be randomized in such a way as to eliminate any interference with the pixel spacing of a liquid crystal display. This randomization can include the size, shape, position, depth, orientation, angle or density of the optical elements. This eliminates the need for diffuser layers to defeat moiré and similar effects. Also, at least some of the individual optical elements may be arranged in groupings across the exit surface of the films, with at least some of the optical elements in each of the groupings having a different size or shape characteristic that collectively produce an average size or shape characteristic for each of the groupings that varies across the films to obtain average characteristic values beyond machining tolerances for any single optical element and to defeat moiré and interference effects with the pixel spacing of a liquid crystal display. In addition, at least some of the individual optical elements may be oriented at different angles relative to each other for customizing the ability of the films to reorient/redirect light along two different axes.

The angles that the light redirecting surfaces of the individual optical elements make with the light exit surface of the films may also be varied across the display area of a liquid crystal display to tailor the light redirecting function of the films to a light input distribution that is non-uniform across the surface of the light source.

The individual optical elements of the light redirecting films also desirably overlap each other, in a staggered, interlocked and/or intersecting configuration, creating an optical structure with excellent surface area coverage. Moreover, the individual optical elements may be arranged in groupings with some of the individual optical elements oriented along one axis and other individual optical elements oriented along another axis. Also, the orientation of the individual optical elements in each grouping may vary. Further, the size, shape, position and/or orientation of the individual optical elements of the light redirecting films may vary to account for variations in the distribution of light emitted by a light source.

The properties and pattern of the optical elements of light redirecting films may also be customized to optimize the light redirecting films for different types of light sources which emit different light distributions, for example, one pattern for single bulb laptops, another pattern for double bulb flat panel displays, and so on.

Further, light redirecting film systems are provided in which the orientation, size, position and/or shape of the individual optical elements of the light redirecting films are tailored to the light output distribution of a backlight or other light source to reorient or redirect more of the incident light from the backlight within a desired viewing angle. Also, the backlight may include individual optical deformities that collimate light along one axis and the light redirecting films may include individual optical elements that collimate light along another axis perpendicular to the one axis.

To the accomplishment of the foregoing and related ends, the invention, then, comprises the features hereinafter more fully described and particularly pointed out in the claims, the following description and annexed drawings setting forth in detail certain illustrative embodiments of the invention, these being indicative, however, of but several of the various ways in which the principles of the invention may be employed.

BRIEF DESCRIPTION OF THE DRAWINGS

In the annexed drawings:

FIG. **1** is a schematic side elevation view of one form of light redirecting film system in accordance with the present invention;

FIG. **2** is an enlarged fragmentary side elevation view of a portion of the backlight and light redirecting film system of FIG. **1**;

FIGS. **3** and **4** are schematic side elevation views of other forms of light redirecting film systems of the present invention;

FIGS. **5-20** are schematic perspective or plan views showing different patterns of individual optical elements on light redirecting films of the present invention;

FIGS. **5***a*-**5***n* are schematic perspective views of different geometric shapes that the individual optical elements on the light redirecting films may take;

FIG. **21** is a schematic perspective view of a light redirecting film having optical grooves extending across the film in a curved pattern facing a corner of the film;

FIG. **22** is a top plan view of a light redirecting film having a pattern of optical grooves extending across the film facing a midpoint on one edge of the film that decreases in curvature as the distance from the one edge increases;

FIG. **23** is an end elevation view of the light redirecting film of FIG. **22** as seen from the left end thereof;

FIG. **24** is a side elevation view of the light redirecting film of FIG. **22**;

FIGS. **25** and **26** are enlarged schematic fragmentary plan views of a surface area of a backlight/light emitting panel assembly showing various forms of optical deformities formed on or in a surface of the backlight;

FIGS. **27** and **28** are enlarged longitudinal sections through one of the optical deformities of FIGS. **25** and **26**, respectively;

FIGS. **29** and **30** are enlarged schematic longitudinal sections through other forms of optical deformities formed on or in a surface of a backlight;

FIGS. **31-39** are enlarged schematic perspective views of backlight surface areas containing various patterns of individual optical deformities of other well defined shapes;

FIG. **40** is an enlarged schematic longitudinal section through another form of optical deformity formed on or in a surface of a backlight;

FIGS. **41** and **42** are enlarged schematic top plan views of backlight surface areas containing optical deformities similar in shape to those shown in FIGS. **37** and **38** arranged in a plurality of straight rows along the length and width of the surface areas;

FIGS. **43** and **44** are enlarged schematic top plan views of backlight surface areas containing optical deformities also similar in shape to those shown in FIGS. **37** and **38** arranged in staggered rows along the length of the surface areas;

FIGS. **45** and **46** are enlarged schematic top plan views of backlight surface areas containing a random or variable pattern of different sized optical deformities on the surface areas;

FIG. **47** is an enlarged schematic perspective view of a backlight surface area showing optical deformities increasing in size as the distance of the deformities from the light input surface increases or intensity of the light increases along the length of the surface area;

FIGS. **48** and **49** are schematic perspective views showing different angular orientations of the optical deformities along the length and width of a backlight surface area; and

FIGS. **50** and **51** are enlarged perspective views schematically showing how exemplary light rays emitted from a focused light source are reflected or refracted by different individual optical deformities of well defined shapes of a backlight surface area.

DETAILED DESCRIPTION OF THE INVENTION

FIGS. **1** and **2** schematically show one form of light redirecting film system **1** in accordance with this invention including a light redirecting film **2** that redistributes more of the light emitted by a backlight BL or other light source toward a direction more normal to the surface of the film. Film **2** may be used to redistribute light within a desired viewing angle from almost any light source for lighting, for example, a display such as a liquid crystal display, used in laptop computers, word processors, avionic displays, cell phones, PDAs and the like, to make the displays brighter. The liquid crystal display can be any type including a transmissive liquid crystal display D as schematically shown in FIGS. **1** and **2**, a reflective liquid crystal display D^{I} as schematically shown in FIG. **3** and a transflective liquid crystal display D^{II} as schematically shown in FIG. **4**.

The reflective liquid crystal display D' shown in FIG. **3** includes a back reflector **42** adjacent the back side for reflecting ambient light entering the display back out the display to increase the brightness of the display. The light redirecting film **2** of the present invention is placed adjacent the top of the reflective liquid crystal display to redirect ambient light (or light from a front light) into the display toward a direction more normal to the plane of the film for reflection back out by the back reflector within a desired viewing angle to increase the brightness of the display. Light redirecting film **2** may be attached to, laminated to or otherwise held in place against the top of the liquid crystal display.

The transflective liquid crystal display D^{II} shown in FIG. **4** includes a transreflector T placed between the display and a backlight BL for reflecting ambient light entering the front of the display back out the display to increase the brightness of the display in a lighted environment, and for transmitting light from the backlight through the transreflector and out the display to illuminate the display in a dark environment. In this embodiment the light redirecting film **2** may either be placed adjacent the top of the display or adjacent the bottom of the display or both as schematically shown in FIG. **4** for redirecting or redistributing ambient light and/or light from the backlight more normal to the plane of the film to make the light ray output distribution more acceptable to travel through the display to increase the brightness of the display.

Light redirecting film **2** comprises a thin transparent film or substrate **8** having a pattern of discrete individual optical elements **5** of well defined shape on the light exit surface **6** of the film for refracting the incident light distribution such that the distribution of the light exiting the film is in a direction more normal to the surface of the film.

Each of the individual optical elements **5** has a width and length many times smaller than the width and length of the film, and may be formed by depressions in or projections on the exit surface of the film. These individual optical elements **5** include at least one sloping surface for refracting the incident light toward the direction normal to the light exit surface. FIG. **5** shows one pattern of individual optical elements **5** on a film **2**. These optical elements may take many different shapes. For example, FIG. **5***a* shows one of the optical elements **5** of FIG. **5** which is a non-prismatic optical element having a total of two surfaces **10**, **12**, both of which are sloping. One of the surfaces **10** shown in FIG. **5***a* is planar or flat whereas the other surface **12** is curved. Moreover, both surfaces **10**, **12** intersect each other and also intersect the surface of the film. Alternatively, both surfaces **10'**, **12'** of the individual optical elements **5'** may be curved as schematically shown in FIG. **5***b*.

Alternatively, the optical elements may each have only one surface that is curved and sloping and intersects the film. FIG. **5***c* shows one such optical element $\mathbf{5}^{II}$ in the shape of a cone **13**, whereas FIG. **5***d* shows another such optical element $\mathbf{5}^{III}$ having a semispherical or dome shape **14**. Also, such optical elements may have more than one sloping surface intersecting the film.

FIG. **5***e* shows an optical element $\mathbf{5}^{IV}$ having a total of three surfaces, all of which intersect the film and intersect each other. Two of the surfaces **15** and **16** are curved, whereas the third surface **17** is planar.

FIG. **5***f* shows an optical element $\mathbf{5}^{V}$ in the shape of a pyramid **18** with four triangular shaped sides **19** that intersect each other and intersect the film. The sides **19** of the pyramid **18** may all be of the same size and shape as shown in FIG. **5***f*, or the sides $\mathbf{19}^{I}$ of the pyramid $\mathbf{18}^{I}$ may be stretched so the sides of the optical element $\mathbf{5}^{VI}$ have different perimeter shapes as shown in FIG. **5***g*. Also, the optical elements may have any number of planar sloping sides. FIG. **5***h* shows an optical element $\mathbf{5}^{VII}$ with four planar sloping sides **20**, whereas FIG. **5***i* shows an optical element $\mathbf{5}^{VIII}$ with eight planar sloping sides $\mathbf{20}^{I}$.

The individual optical elements may also have more than one curved and more than one planar sloping surface, all intersecting the film. FIG. **5***j* shows an optical element $\mathbf{5}^{IX}$ having a pair of intersecting oppositely sloping planar sides **22** and oppositely rounded or curved ends or sides **23**. Further, the sloping planar sides $\mathbf{22}^{I}$ and $\mathbf{22}^{II}$ and curved ends or sides $\mathbf{23}^{I}$ and $\mathbf{23}^{II}$ of optical elements **5**× and $\mathbf{5}^{xi}$ may have different angled slopes as shown in FIGS. **5***k* and **5***l*. Moreover, the optical elements may have at least one curved surface that does not intersect the film. One such optical element $\mathbf{5}^{XII}$ is shown in FIG. **5***m* which includes a pair of oppositely sloping planar sides $\mathbf{22}^{III}$ and oppositely rounded or curved ends or sides $\mathbf{23}^{III}$ and a rounded or curved top **24** intersecting the oppositely sloping sides and oppositely rounded ends. Further, the optical elements $\mathbf{5}^{XIII}$ may be curved along their length as shown in FIG. **5***n*.

Providing the individual optical elements with a combination of planar and curved surfaces redirects or redistributes a larger viewing area than is possible with a grooved film. Also, the curvature of the surfaces, or the ratio of the curved area to the planar area of the individual optical elements may be varied to tailor the light output distribution of the film to customize the viewing area of a display device used in conjunction with the film.

The light entrance surface **7** of the film **2** may have an optical coating **25** (see FIG. **2**) such as an antireflective coating, a reflective polarizer, a retardation coating or a polarizer. Also, a matte or diffuse texture may be provided on the light

entrance surface **7** depending on the visual appearance desired. A matte finish produces a softer image but is not as bright. The combination of planar and curved surfaces of the individual optical elements of the present invention may be configured to redirect some of the light rays impinging thereon in different directions to produce a softer image without the need for an additional diffuser or matte finish on the entrance surface of the film.

The individual optical elements of the light redirecting film also desirably overlap each other in a staggered, interlocked and/or intersecting configuration, creating an optical structure with excellent surface area coverage. FIGS. **6**, **7**, **13** and **15**, for example, show optical elements $\mathbf{5}^{XIV}$, $\mathbf{5}^{XV}$, $\mathbf{5}^{XVI}$, and $\mathbf{5}^{XVII}$ of light redirecting films $\mathbf{2}^{I}$, $\mathbf{2}^{II}$, $\mathbf{2}^{III}$ and $\mathbf{2}^{IV}$ staggered with respect to each other; FIGS. **8-10** show the optical elements $\mathbf{5}^{XVIII}$, $\mathbf{5}^{XIX}$ and $\mathbf{5}^{XX}$ of light redirecting films $\mathbf{2}^{V}$, $\mathbf{2}^{VI}$ and $\mathbf{2}^{VII}$ intersecting each other; and FIGS. **11** and **12** show the optical elements intersecting $\mathbf{5}^{XXI}$ and $\mathbf{5}^{XXII}$ of light redirecting films $\mathbf{2}^{VIII}$ and $\mathbf{2}^{IX}$ interlocking each other.

Moreover, the slope angle, density, position, orientation, height or depth, shape, and/or size of the optical elements of the light redirecting film may be matched or tuned to the particular light output distribution of a backlight BL or other light source to account for variations in the distribution of light emitted by the backlight in order to redistribute more of the light emitted by the backlight within a desired viewing angle. For example, the angle that the sloping surfaces (e.g., surfaces **10**, **12**) of the optical elements **5** make with the surface of the light redirecting film **2** may be varied as the distance from the backlight BL from a light source **26** increases to account for the way the backlight emits light rays R at different angles as the distance from the light source increases as schematically shown in FIG. **2**. Also, the backlight BL itself may be designed to emit more of the light rays at lower angles to increase the amount of light emitted by the backlight and rely on the light redirecting film to redistribute more of the emitted light within a desired viewing angle. In this way the individual optical elements of the light redirecting film may be selected to work in conjunction with the optical deformations of the backlight to produce an optimized output light ray angle distribution from the system.

FIGS. **2**, **5** and **9** show different patterns of individual optical elements all of the same height or depth, whereas FIGS. **7**, **8**, **10**, **13** and **14** show different patterns of individual optical elements of different shapes, sizes and height or depth. The individual optical elements $\mathbf{5}^{XXIII}$ of the light redirecting film $\mathbf{2}^{X}$ of FIG. **14** are also shown arranged in alternating rows along the width or length of the film.

The individual optical elements $\mathbf{5}^{XXV}$ and $\mathbf{5}^{XXVI}$ may also be randomized on the film $\mathbf{2}^{XI}$ and $\mathbf{2}^{XII}$ as schematically shown in FIGS. **16** and **17** in such a way as to eliminate any interference with the pixel spacing of a liquid crystal display. This eliminates the need for optical diffuser layers **30** shown in FIGS. **1** and **2** to defeat moiré and similar effects. Moreover, at least some of the individual optical elements may be arranged in groupings **32**, $\mathbf{32}^{I}$ and $\mathbf{32}^{II}$ across the film, with at least some of the optical elements in each grouping having a different size or shape characteristic that collectively produce an average size or shape characteristic for each of the groupings that varies across the film as schematically shown in FIGS. **7**, **13** and **15** to obtain characteristic values beyond machining tolerances to defeat moiré and interference effects with the liquid crystal display pixel spacing. For example, at least some of the optical elements in each grouping may have a different depth or height that collectively produce an average depth or height characteristic for each grouping that varies across the film. Also, at least some of the optical elements in each grouping may have a different slope angle that collectively produce an average slope angle for each grouping that varies across the film. Further, at least one sloping surface of the individual optical elements in each grouping may have a different width or length that collectively produce an average width or length characteristic in each grouping that varies across the film.

Where the individual optical elements include a combination of planar and curved surfaces, for example planar and curved surfaces $\mathbf{10}^{II}$, $\mathbf{12}^{II}$, $\mathbf{10}^{III}$, $\mathbf{12}^{III}$ and $\mathbf{10}^{IV}$, $\mathbf{12}^{IV}$ as shown in FIGS. **7**, **13** and **15**, respectively, the curvature of the curved surfaces, or the ratio of the curved area to the planar area of the individual optical elements as well as the perimeter shapes of the curved and planar surfaces may be varied to tailor the light output distribution of the film. In addition, the curvature of the curved surfaces, or the ratio of the curved area to the planar area of the individual optical elements may be varied to redirect more or less light that is traveling in a plane that would be parallel to the grooves of a prismatic or lenticular grooved film, partially or completely replacing the need for a second layer of light redirecting film. Also, at least some of the individual optical elements may be oriented at different angles relative to each other as schematically shown in FIGS. **13** and **16** to redistribute more of the light emitted by a light source along two different axes in a direction more normal to the surface of the film, partially or completely replacing the need for a second layer of light redirecting film. However, it will be appreciated that two layers of such light redirecting film each having the same or different patterns of individual optical elements thereon may be placed between a light source and viewing area with the layers rotated 90 degrees (or other angles greater than 0 degrees and less than 90 degrees) with respect to each other so that the individual optical elements on the respective film layers redistribute more of the light emitted by a light source traveling in different planar directions in a direction more normal to the surface of the respective films.

Also, the light redirecting film $\mathbf{2}^{IV}$ may have a pattern of optical elements $\mathbf{5}^{XVII}$ that varies at different locations on the film as schematically shown in FIG. **15** to redistribute the light ray output distribution from different locations of a backlight or other light source to redistribute the light ray output distribution from the different locations toward a direction normal to the film.

Further, the properties and pattern of the optical elements of the light redirecting film may be customized to optimize the light redirecting film for different types of light sources which emit different light distributions, for example, one pattern for single bulb laptops, another pattern for double bulb flat panel displays, and so on.

FIG. **17** shows the optical elements $\mathbf{5}^{XXVI}$ arranged in a radial pattern from the outside edges of the film $\mathbf{2}^{XII}$ toward the center to redistribute the light ray output distribution of a backlight BL that receives light from cold cathode fluorescent lamp $\mathbf{26}^{I}$ along all four side edges of the backlight.

FIG. **18** shows the optical elements $\mathbf{5}^{XXVII}$ arranged in a pattern of angled groupings $\mathbf{32}^{III}$ across the film **2** that are tailored to redistribute the light ray output distribution of a backlight BL that receives light from one cold cathode fluorescent lamp $\mathbf{26}^{I}$ or a plurality of light emitting diodes $\mathbf{26}^{II}$ along one input edge of the backlight.

FIG. **19** shows the optical elements $\mathbf{5}^{XXVIII}$ arranged in a radial type pattern facing a corner of the film $\mathbf{2}^{XIV}$ to redistribute the light ray output distribution of a backlight BL that is corner lit by a light emitting diode $\mathbf{26}^{II}$. FIG. **20** shows the optical elements $\mathbf{5}^{XXIX}$ arranged in a radial type pattern facing a midpoint on one input edge of the film $\mathbf{2}^{XV}$ to redistribute the

light ray output distribution of a backlight BL that is lighted at a midpoint of one input edge of the backlight by a single light emitting diode **26**^{II}.

FIG. **21** shows a light redirecting film **2**^{XVI} having optical grooves **35** extending across the film in a curved pattern facing a corner of the film to redistribute the light ray output distribution of a backlight BL that is corner lit by a light emitting diode **26**^{II}, whereas FIGS. **22-24** show a light redirecting film **2**^{XVII} having a pattern of optical grooves **35**^{I} extending across the film facing a midpoint along one edge of the film that decreases in curvature as the distance from the one edge increases to redistribute the light ray output distribution of a backlight BL that is edge lit by a light emitting diode **26**^{II} at a midpoint of one input edge of the backlight.

Where the light redirecting film has a pattern **40** of optical elements **5** thereon that varies along the length of the film, a roll **41** of the film may be provided having a repeating pattern of optical elements thereon as schematically shown in FIG. **15** to permit a selected area of the pattern that best suits a particular application to be die cut from the roll of film.

The backlight BL may be substantially flat, or curved, or may be a single layer or multi-layers, and may have different thicknesses and shapes as desired. Moreover, the backlight may be flexible or rigid, and be made of a variety of compounds. Further, the backlight may be hollow, filled with liquid, air, or be solid, and may have holes or ridges.

Also, the light source **26** may be of any suitable type including, for example, an arc lamp, an incandescent bulb which may also be colored, filtered or painted, a lens end bulb, a line light, a halogen lamp, a light emitting diode (LED), a chip from an LED, a neon bulb, a cold cathode fluorescent lamp, a fiber optic light pipe transmitting from a remote source, a laser or laser diode, or any other suitable light source. Additionally, the light source **26** may be a multiple colored LED, or a combination of multiple colored radiation sources in order to provide a desired colored or white light output distribution. For example, a plurality of colored lights such as LEDs of different colors (e.g., red, blue, green) or a single LED with multiple color chips may be employed to create white light or any other colored light output distribution by varying the intensities of each individual colored light.

A pattern of optical deformities may be provided on one or both sides of the backlight BL or on one or more selected areas on one or both sides of the backlight as desired. As used herein, the term optical deformities means any change in the shape or geometry of a surface and/or coating or surface treatment that causes a portion of the light to be emitted from the backlight. These deformities can be produced in a variety of manners, for example, by providing a painted pattern, an etched pattern, machined pattern, a printed pattern, a hot stamp pattern, or a molded pattern or the like on selected areas of the backlight. An ink or print pattern may be applied for example by pad printing, silk printing, inkjet, heat transfer film process or the like. The deformities may also be printed on a sheet or film which is used to apply the deformities to the backlight. This sheet or film may become a permanent part of the backlight for example by attaching or otherwise positioning the sheet or film against one or both sides of the backlight in order to produce a desired effect.

By varying the density, opaqueness or translucence, shape, depth, color, area, index of refraction or type of deformities on or in an area or areas of the backlight, the light output of the backlight can be controlled. The deformities may be used to control the percent of light output from a light emitting area of the backlight. For example, less and/or smaller size deformities may be placed on surface areas where less light output is wanted. Conversely, a greater percentage of and/or larger deformities may be placed on surface areas of the backlight where greater light output is desired.

Varying the percentages and/or size of deformities in different areas of the backlight is necessary in order to provide a substantially uniform light output distribution. For example, the amount of light traveling through the backlight will ordinarily be greater in areas closer to the light source than in other areas further removed from the light source. A pattern of deformities may be used to adjust for the light variances within the backlight, for example, by providing a denser concentration of deformities with increased distance from the light source thereby resulting in a more uniform light output distribution from the backlight.

The deformities may also be used to control the output ray angle distribution from the backlight to suit a particular application. For example, if the backlight is used to backlight a liquid crystal display, the light output will be more efficient if the deformities (or a light redirecting film is used in combination with the backlight) direct the light rays emitted by the backlight at predetermined ray angles such that they will pass through the liquid crystal display with low loss. Additionally, the pattern of optical deformities may be used to adjust for light output variances attributed to light extractions of the backlight. The pattern of optical deformities may be printed on the backlight surface areas utilizing a wide spectrum of paints, inks, coatings, epoxies or the like, ranging from glossy to opaque or both, and may employ half-tone separation techniques to vary the deformity coverage. Moreover, the pattern of optical deformities may be multiple layers or vary in index of refraction.

Print patterns of optical deformities may vary in shapes such as dots, squares, diamonds, ellipses, stars, random shapes, and the like. Also, print patterns of sixty lines per inch or finer are desirably employed. This makes the deformities or shapes in the print patterns nearly invisible to the human eye in a particular application, thereby eliminating the detection of gradient or banding lines that are common to light extracting patterns utilizing larger elements. Additionally, the deformities may vary in shape and/or size along the length and/or width of the backlight. Also, a random placement pattern of the deformities may be utilized throughout the length and/or width of the backlight. The deformities may have shapes or a pattern with no specific angles to reduce moiré or other interference effects. Examples of methods to create these random patterns are printing a pattern of shapes using stochastic print pattern techniques, frequency modulated half tone patterns, or random dot half tones. Moreover, the deformities may be colored in order to effect color correction in the backlight. The color of the deformities may also vary throughout the backlight, for example, to provide different colors for the same or different light output areas.

In addition to or in lieu of the patterns of optical deformities, other optical deformities including prismatic or lenticular grooves or cross grooves, or depressions or raised surfaces of various shapes using more complex shapes in a mold pattern may be molded, etched, stamped, thermoformed, hot stamped or the like into or on one or more surface areas of the backlight. The prismatic or lenticular surfaces, depressions or raised surfaces will cause a portion of the light rays contacted thereby to be emitted from the backlight. Also, the angles of the prisms, depressions or other surfaces may be varied to direct the light in different directions to produce a desired light output distribution or effect. Moreover, the reflective or refractive surfaces may have shapes or a pattern with no specific angles to reduce moiré or other interference effects.

A back reflector **42** may be attached or positioned against one side of the backlight BL as schematically shown in FIGS.

1 and 2 in order to improve light output efficiency of the backlight by reflecting the light emitted from that side back through the backlight for emission through the opposite side. Additionally, a pattern of optical deformities **50** may be provided on one or both sides of the backlight as schematically shown in FIGS. **1** and **2** in order to change the path of the light so that the internal critical angle is exceeded and a portion of the light is emitted from one or both sides of the backlight.

FIGS. **25-28** show optical deformities **50**^{I}, **50**^{II} which may either be individual projections **51** on the respective backlight surface areas **52** or individual depressions **53** in such surface areas **52**^{I} of a backlight BI^{I}, BL^{II}. In either case, each of these optical deformities has a well defined shape including a reflective or refractive surface **54**, **54**^{I} (hereafter sometimes collectively referred to as a reflective/refractive surface) that intersects the respective backlight surface area **52**, **52**^{I} at one edge **55**, **55**^{I} and has a uniform slope throughout its length for more precisely controlling the emission of light by each of the deformities. Along a peripheral edge portion **56**, **56**^{I} of each reflective/refractive surface **54**, **54**^{I} is an end wall **57**, **57**^{I} of each deformity that intersects the respective panel surface area **52**, **52**^{I} at a greater included angle I, I^{I} than the included angle I^{II}, I^{III} between the reflective/refractive surfaces **54**, **54**^{I} and the panel surface area **52**, **52**^{I} (see FIGS. **27** and **28**) to minimize the projected surface area of the end walls on the panel surface area. This allows more deformities to be placed on or in the panel surface areas than would otherwise be possible if the projected surface areas of the end walls **57**, **57**^{I} were substantially the same as or greater than the projected surface areas of the reflective/refractive surfaces **54**, **54**^{I}.

In FIGS. **25** and **26** the peripheral edge portions **56**, **56**^{I} of the reflective/refractive surfaces **54**, **54**^{I} and associated end walls **57**, **57**^{I} are curved in the transverse direction. Also in FIGS. **27** and **28** the end walls **57**, **57**^{I} of the deformities are shown extending substantially perpendicular to the reflective/refractive surfaces **54**, **54**^{I} of the deformities. Alternatively, such end walls may extend substantially perpendicular to the panel surface areas **52**, **52**^{I} as schematically shown in FIGS. **29** and **30**. This virtually eliminates any projected surface area of the end walls on the panel surface areas whereby the density of the deformities on the panel surface areas may be even further increased.

The optical deformities may also be of other well defined shapes to obtain a desired light output distribution from a panel surface area. FIG. **31** shows individual light extracting deformities **58** on a panel surface area **52**^{III} each including a generally planar, rectangular reflective/refractive surface **59** and associated end wall **60** of a uniform slope throughout their length and width and generally planar side walls **61**. Alternatively, the deformities **58**^{I} may have rounded or curved side walls **62** on a panel surface area **52**^{IV} as schematically shown in FIG. **32**.

FIG. **33** shows individual light extracting deformities **63** on a panel surface area **52**^{V} each including a planar, sloping triangular shaped reflective/refractive surface **64** and associated planar, generally triangularly shaped side walls or end walls **65**. FIG. **34** shows individual light extracting deformities **66** on a panel surface area **52**^{VI} each including a planar sloping reflective/refractive surface **67** having angled peripheral edge portions **68** and associated angled end and side walls **69** and **70**.

FIG. **35** shows individual light extracting deformities **71** on a panel surface area **52**^{VII} which are generally conically shaped, whereas FIG. **36** shows individual light extracting deformities **72** on a panel surface area **52**^{VIII} each including a rounded reflective/refractive surface **73** and rounded end walls **74** and rounded or curved side walls **75** all blended together. These additional surfaces will reflect or refract other light rays impinging thereon in different directions to spread light across the backlight/panel member BL to provide a more uniform distribution of light emitted from the panel member.

Regardless of the particular shape of the reflective/refractive surfaces and end and side walls of the individual deformities, such deformities may also include planar surfaces intersecting the reflective/refractive surfaces and end and/or side walls in parallel spaced relation to the panel surface areas **52**. FIGS. **37-39** show deformities **76**, **77** and **78** in the form of individual projections on a panel surface area **52**^{IX}, **52**^{X}, **52**^{XI} having representative shapes similar to those shown in FIGS. **31**, **32** and **35**, respectively, except that each deformity is intersected by a planar surface **79**, **79**^{I}, **79**^{II} in parallel spaced relation to the panel surface area. In like manner, FIG. **40** shows one of a multitude of deformities **80** in the form of individual depressions **81** in a panel surface area **52**^{XII} each intersected by a planar surface **79**^{III} in parallel spaced relation to the general planar surface of the panel surface area. Any light rays that impinge on such planar surfaces at internal angles less than the critical angle for emission of light from the panel surface area will be internally reflected by the planar surfaces, whereas any light rays impinging on such planar surfaces at internal angles greater than the critical angle will be emitted by the planar surfaces with minimal optical discontinuities, as schematically shown in FIG. **40**.

Where the deformities are projections on the panel surface area, the reflective/refractive surfaces extend at an angle away from the panel in a direction generally opposite to that in which the light rays from the light source **26** travel through the panel as schematically shown in FIGS. **27** and **29**. Where the deformities are depressions in the panel surface area, the reflective/refractive surfaces extend at an angle into the panel in the same general direction in which the light rays from the light source **26** travel through the panel member as schematically shown in FIGS. **28** and **30**.

Regardless of whether the deformities are projections or depressions on or in the panel surface areas, the slopes of the light reflective/refractive surfaces of the deformities may be varied to cause the light rays impinging thereon to be either refracted out of the light emitting panel or reflected back through the panel and emitted out the opposite side of the panel which may be etched to diffuse the light emitted therefrom or covered by a light redirecting film to produce a desired effect. Also, the pattern of optical deformities on the panel surface area may be uniform or variable as desired to obtain a desired light output distribution from the panel surface areas. FIGS. **41** and **42** show deformities **76**^{I} and **77**^{I} similar in shape to those shown in FIGS. **37** and **38** arranged in a plurality of generally straight uniformly spaced apart rows along the length and width of a panel surface area **52**^{XIII}, **52**^{XIV}, whereas FIGS. **43** and **44** show such deformities **76**^{II} and **77**^{II} arranged in staggered rows that overlap each other along the length of a panel surface area **52**^{XV}, **52**^{XVI}.

Also, the size, including the width, length and depth or height as well as the angular orientation and position of the optical deformities may vary along the length and/or width of any given panel surface area to obtain a desired light output distribution from the panel surface area. FIGS. **45** and **46** show a random or variable pattern of different size deformities **58**^{II}, **58**^{III} similar in shape to those shown in FIGS. **31** and **32**, respectively, arranged in staggered rows on a panel surface area **52**^{XVII}, **52**^{XVIII}, whereas FIG. **47** shows deformities **77**^{III} similar in shape to those shown in FIG. **38** increasing in size as the distance of the deformities from the light source increases or intensity of the light decreases along the length and/or width of the panel surface area **52**^{XIX}. The deformities

are shown in FIGS. **45** and **46** arranged in clusters **82**, **82**^{I} across the panel surface, with at least some of the deformities in each cluster having a different size or shape characteristic that collectively produce an average size or shape characteristic for each of the clusters that varies across the panel surface. For example, at least some of the deformities in each of the clusters may have a different depth or height or different slope or orientation that collectively produce an average depth or height characteristic or average slope or orientation of the sloping surface that varies across the panel surface. Likewise at least some of the deformities in each of the clusters may have a different width or length that collectively produce an average width or length characteristic that varies across the panel surface. This allows one to obtain a desired size or shape characteristic beyond machinery tolerances, and also defeats moiré and interference effects.

FIGS. **48** and **49** schematically show different angular orientations of optical deformities **85**, **85**^{I} of any desired shape along the length and width of a panel surface area **52**^{XX}, **52**^{XXI} of a light emitting panel assembly backlight. In FIG. **48** the deformities are arranged in straight rows **86** along the length of the panel surface area but the deformities in each of the rows are oriented to face the light source **26** so that all of the deformities are substantially in line with the light rays being emitted from the light source. In FIG. **49** the deformities **85**^{I} are also oriented to face the light source **26** similar to FIG. **48**. In addition, the rows **87** of deformities in FIG. **49** are in substantial radial alignment with the light source **26**.

FIGS. **50** and **51** schematically show how exemplary light rays **90**, **90**^{I} emitted from a focused light source **26** insert molded or cast within a light transition area **91**, **91**^{I} of a light emitting panel assembly backlight BL^{III}, BL^{IV} in accordance with this invention are reflected during their travel through the light emitting panel member **92**, **92**^{I} until they impinge upon individual light extracting deformities **50**^{III}, **77**^{IV} of well defined shapes on or in a panel surface area **52**^{XXII}, **52**^{XXIII} causing more of the light rays to be reflected or refracted out of one side **93**, **93**^{I} of the panel member than the other side **94**, **94**^{I}. In FIG. **50** the exemplary light rays **90** are shown being reflected by the reflective/refractive surfaces **54**^{III} of the deformities **50**^{III} in the same general direction out through the same side **93** of the panel member, whereas in FIG. **51** the light rays **90**^{I} are shown being scattered in different directions within the panel member **92**^{I} by the rounded side walls **62**^{I} of the deformities **77**^{IV} before the light rays are reflected/refracted out of the same side **93**^{I} of the panel member. Such a pattern of individual light extracting deformities of well defined shapes in accordance with the present invention can cause 60 to 70% or more of the light received through the input edge **95**^{I} of the panel member to be emitted from the same side of the panel member.

From the foregoing, it will be apparent that the light redirecting films of the present invention redistribute more of the light emitted by a backlight or other light source toward a direction more normal to the plane of the films. Also, the light redirecting films and backlights of the present invention may be tailored or tuned to each other to provide a system in which the individual optical elements of the light redirecting films work in conjunction with the optical deformities of the backlights to produce an optimized output light ray angle distribution from the system.

Although the invention has been shown and described with respect to certain embodiments, it is obvious that equivalent alterations and modifications will occur to others skilled in the art upon the reading and understanding of the specification. In particular, with regard to the various functions performed by the above described components, the terms (including any reference to a "means") used to describe such components are intended to correspond, unless otherwise indicated, to any component which performs the specified function of the described component (e.g., that is functionally equivalent), even though not structurally equivalent to the disclosed component which performs the function in the herein illustrated exemplary embodiments of the invention. In addition, while a particular feature of the invention may have been disclosed with respect to only one embodiment, such feature may be combined with one or more other features of other embodiments as may be desired and advantageous for any given or particular application.

What is claimed is:

1. A light redirecting film system comprising a backlight including at least one input edge for receiving light from a light source, and at least one light output surface for emitting light, the backlight having deformities that cause most of the light entering the input edge to be emitted from the light output surface at relatively low angles, and a light redirecting film in close proximity to the light output surface for receiving light emitted from the light output surface, the light redirecting film having a pattern of individual optical elements of well-defined shape that vary at different locations on the film to redistribute the light emitted from the light output surface toward a direction normal to the film.

2. The system of claim **1** wherein the deformities of the backlight cause most of the light to be emitted from the light output surface at angles substantially greater than ninety degrees away from the input edge.

3. The system of claim **1** wherein the size or shape of the optical elements are tailored to redistribute more of the light emitted from the light output surface of the backlight within a desired viewing angle.

4. The system of claim **1** wherein at least some of the optical elements are oriented at different angles.

5. The system of claim **1** wherein at least some of the optical elements have different slope angles.

6. The system of claim **1** wherein at least some of the optical elements are oriented at different angles across the film to redistribute the light along two different axes.

7. The system of claim **1** wherein the size of at least some of the optical elements varies across the film.

8. The system of claim **1** wherein the density of the optical elements varies across the film.

9. The system of claim **1** wherein the optical elements comprise depressions in or projections on the film.

10. The system of claim **1** further comprising a liquid crystal display in close proximity to the film, wherein the variations in the pattern of optical elements on the film cause a change in angle of a light ray output distribution from the light output surface to make the light ray output distribution more acceptable to travel through the liquid crystal display.

11. The system of claim **1** wherein the optical elements on the film are randomized in size, shape, position, depth, orientation, angle or density.

12. The system of claim **1** wherein at least some of the optical elements include a combination of planar and curved surfaces.

13. The system of claim **12** wherein the ratio of the areas of the planar and curved surfaces is selected to produce a desired viewing angle.

14. The system of claim **1** wherein at least some of the optical elements overlap each other.

15. The system of claim **14** wherein at least some of the optical elements intersect each other.

16. The system of claim **14** wherein at least some of the optical elements interlock each other.

17. The system of claim **14** wherein at least some of the optical elements are staggered with respect to each other.

18. The system of claim **1** wherein the deformities of the backlight partially collimate light along one axis, and the optical elements of the film partially collimate the light emitted by the backlight along another axis perpendicular to the one axis.

19. The system of claim **18** wherein at least some of the optical elements are quite small in relation to the width and length of the film and differ in size or shape to redistribute more of the light emitted by the backlight.

20. The system of claim **18** wherein at least some of the optical elements are oriented at different angles relative to each other to redistribute more of the light emitted by the backlight within a desired viewing angle.

21. The system of claim **18** wherein at least some of the optical elements are randomly distributed across the film.

22. A light redirecting film system comprising a backlight including at least one input edge for receiving light from a light source, and at least one light output surface for emitting light, the backlight having individual optical deformities of well-defined shape for causing 60 to 70% or more of the light received through the input edge to be reflected or refracted out of the light output surface, and a light redirecting film in close proximity to the light output surface for receiving light emitted from the light output surface, the light redirecting film having a pattern of individual optical elements of well-defined shape to redistribute the light emitted by the backlight toward a direction normal to the film.

23. The system of claim **22** wherein at least some of the deformities have rounded side walls for scattering the light in different directions within the backlight before the light is reflected or refracted out of the one output surface of the backlight.

24. The system of claim **22** wherein a plurality of focused light sources are positioned in laterally spaced relation along the input edge.

25. The system of claim **24** wherein the focused light sources are LEDs.

* * * * *

EXHIBIT D

US008215816B2

(12) **United States Patent**
Parker

(10) **Patent No.: US 8,215,816 B2**
(45) **Date of Patent: *Jul. 10, 2012**

(54) **LIGHT EMITTING PANEL ASSEMBLIES**

(75) Inventor: **Jeffery R. Parker**, Richfield, OH (US)

(73) Assignee: **Rambus International Ltd.** (KY)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **13/315,412**

(22) Filed: **Dec. 9, 2011**

(65) **Prior Publication Data**

US 2012/0081921 A1 Apr. 5, 2012

Related U.S. Application Data

(60) Continuation of application No. 12/940,424, filed on Nov. 5, 2010, now Pat. No. 8,142,063, which is a continuation of application No. 12/488,617, filed on Jun. 22, 2009, now abandoned, which is a continuation of application No. 12/246,613, filed on Oct. 7, 2008, now abandoned, which is a division of application No. 11/504,203, filed on Aug. 15, 2006, now Pat. No. 7,467,887, which is a continuation of application No. 10/784,527, filed on Feb. 23, 2004, now Pat. No. 7,160,015, which is a division of application No. 09/256,275, filed on Feb. 23, 1999, now Pat. No. 6,712,481, which is a continuation-in-part of application No. 08/778,089, filed on Jan. 2, 1997, now Pat. No. 6,079,838, which is a division of application No. 08/495,176, filed on Jun. 27, 1995, now Pat. No. 5,613,751.

(51) **Int. Cl.**
F21V 7/04 (2006.01)

(52) **U.S. Cl.** **362/609**; 362/606; 362/608; 362/619

(58) **Field of Classification Search** 362/603, 362/606, 608, 612, 618, 619, 621, 623, 632–634, 362/609, 613

See application file for complete search history.

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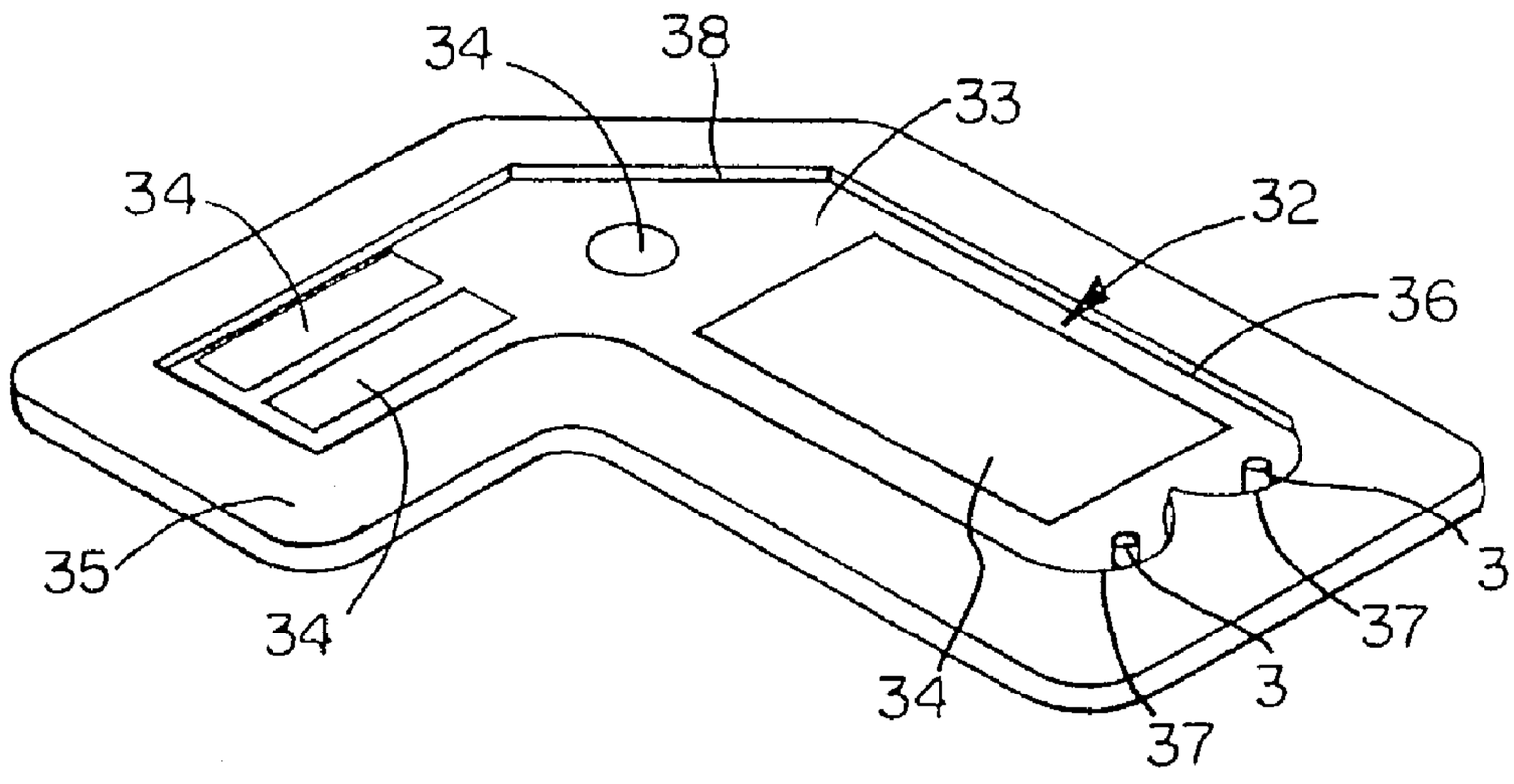
(57) **ABSTRACT**

A light emitting assembly comprises a light source, a light emitting panel member having an input edge that receives light from the light source, and end edge and side edge reflectors. The panel member is received in a cavity or recess of a tray or housing. An additional component overlies the panel member. Light extracting deformities on or in a surface of the panel member cause light to be emitted from the panel member.

4 Claims, 4 Drawing Sheets



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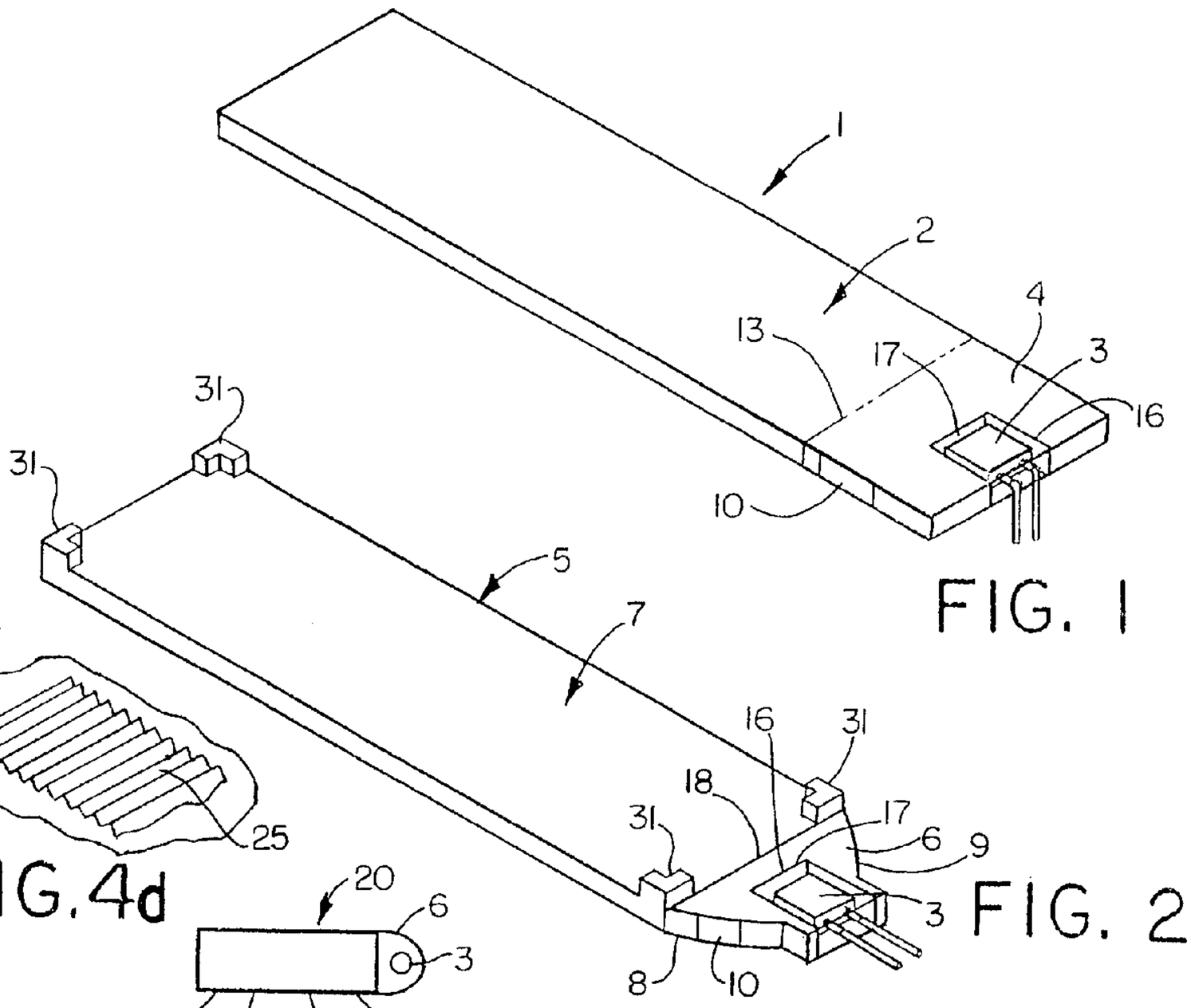

FIG. 1

FIG. 4d

FIG. 2

FIG. 4a

FIG. 4b

FIG. 4c

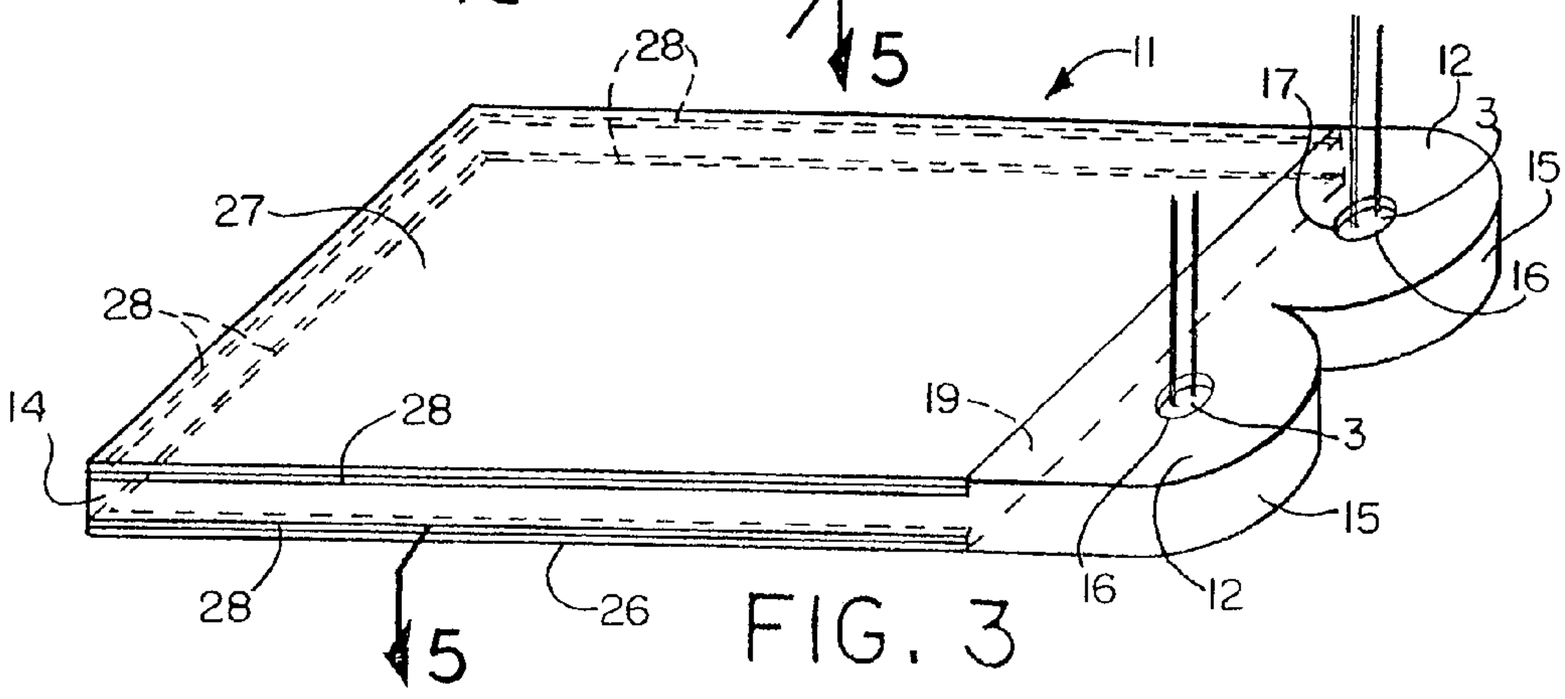

FIG. 3

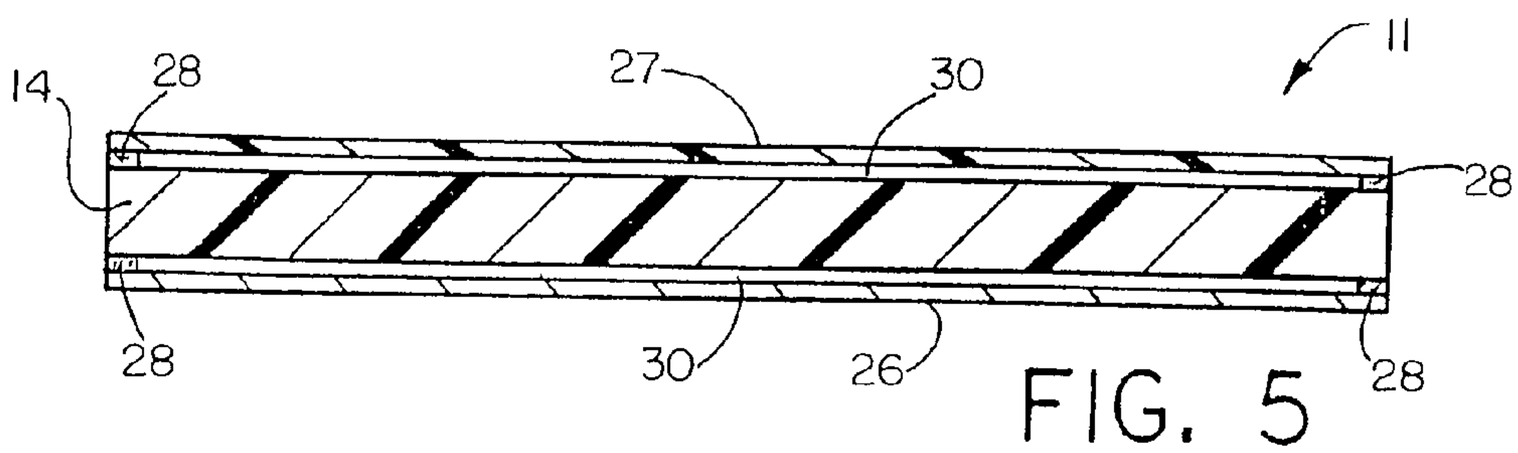

FIG. 5

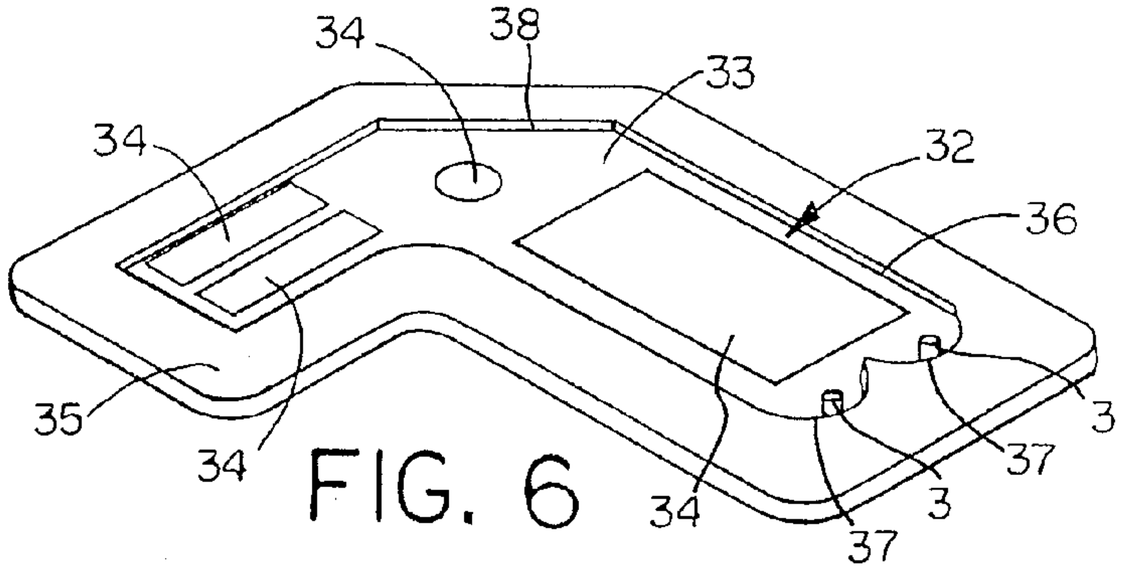

FIG. 6

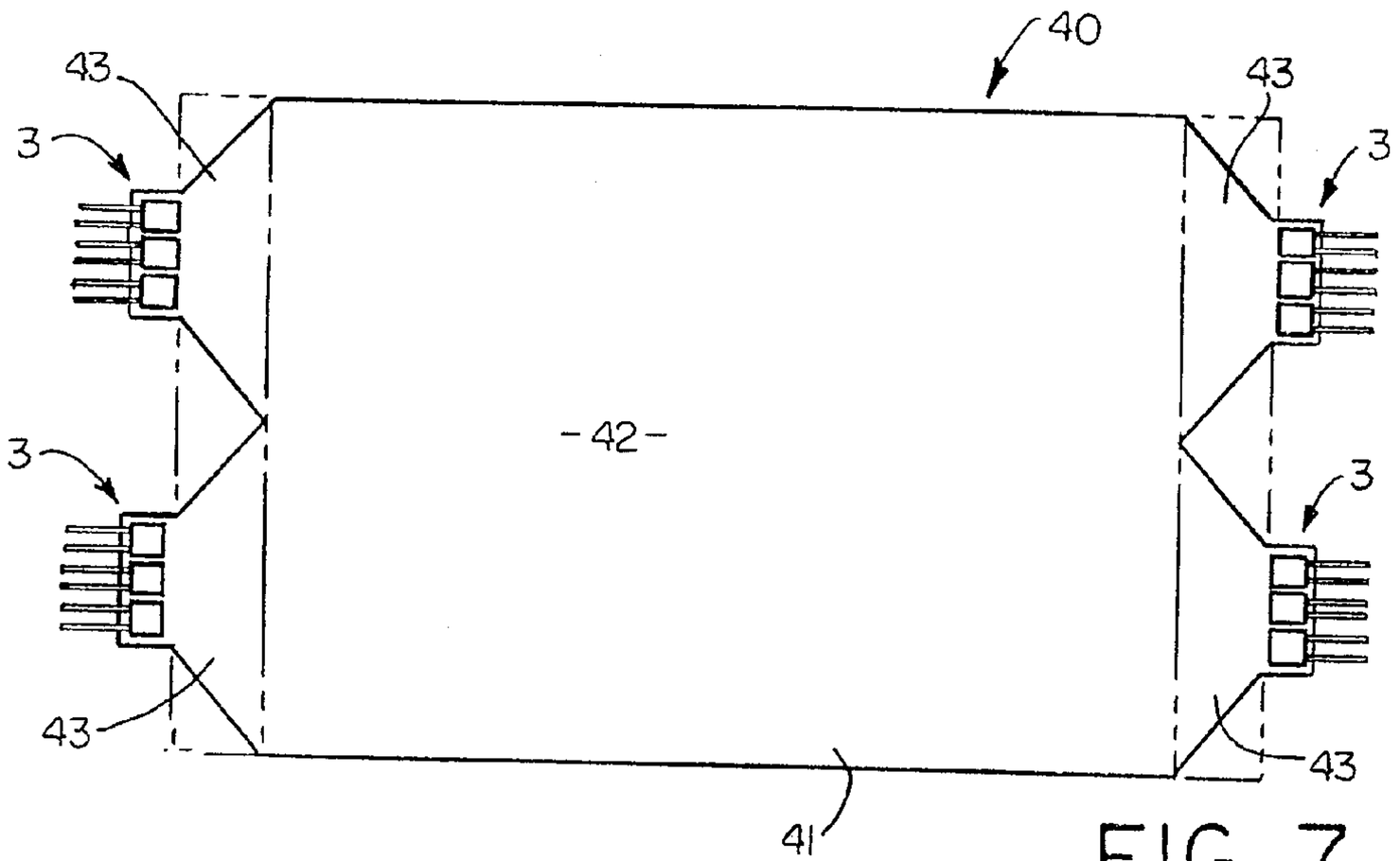

FIG. 7

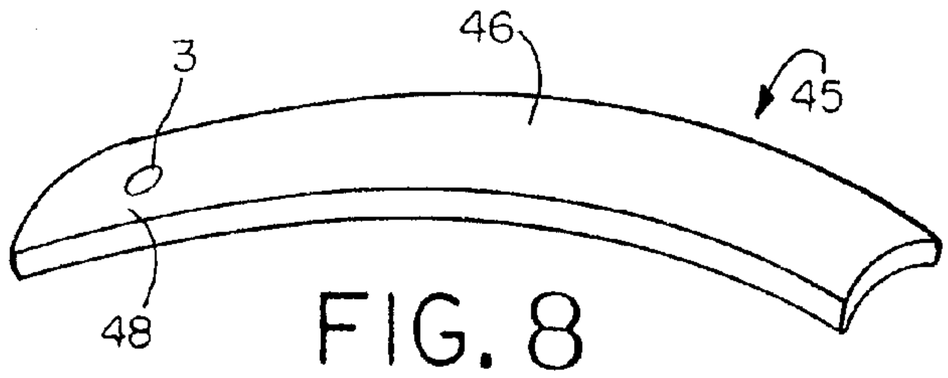

FIG. 8

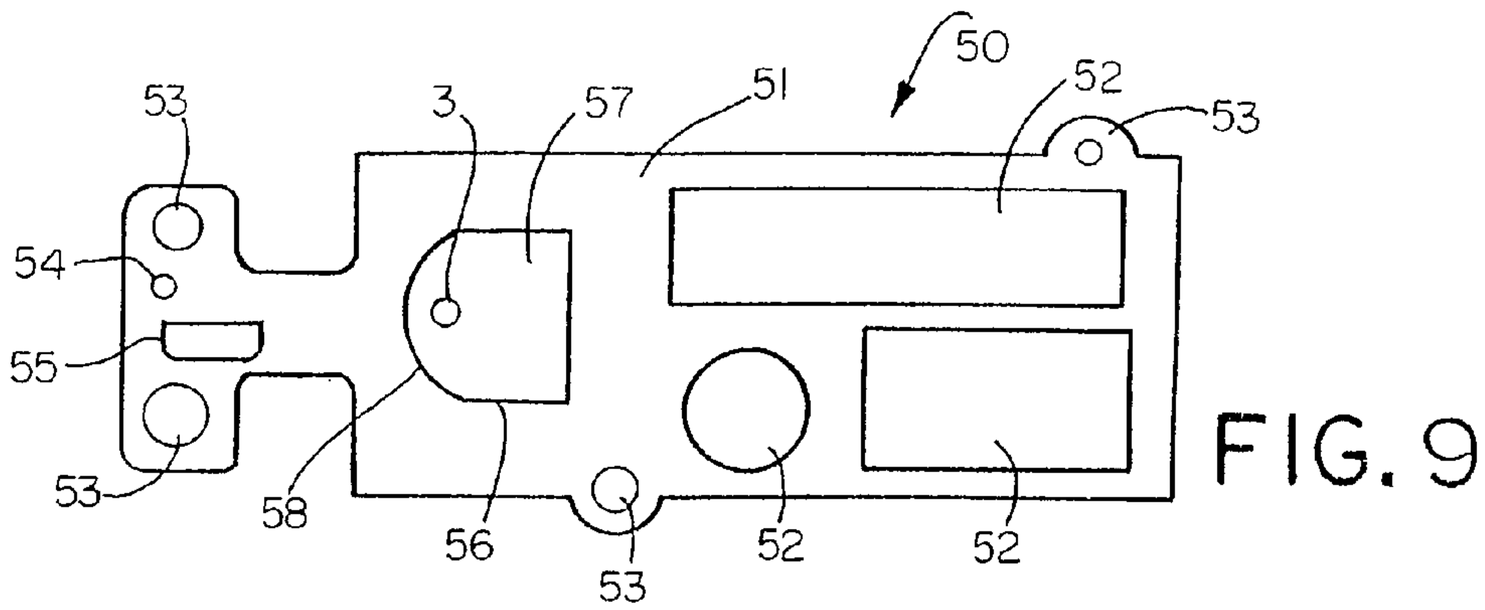

FIG. 9

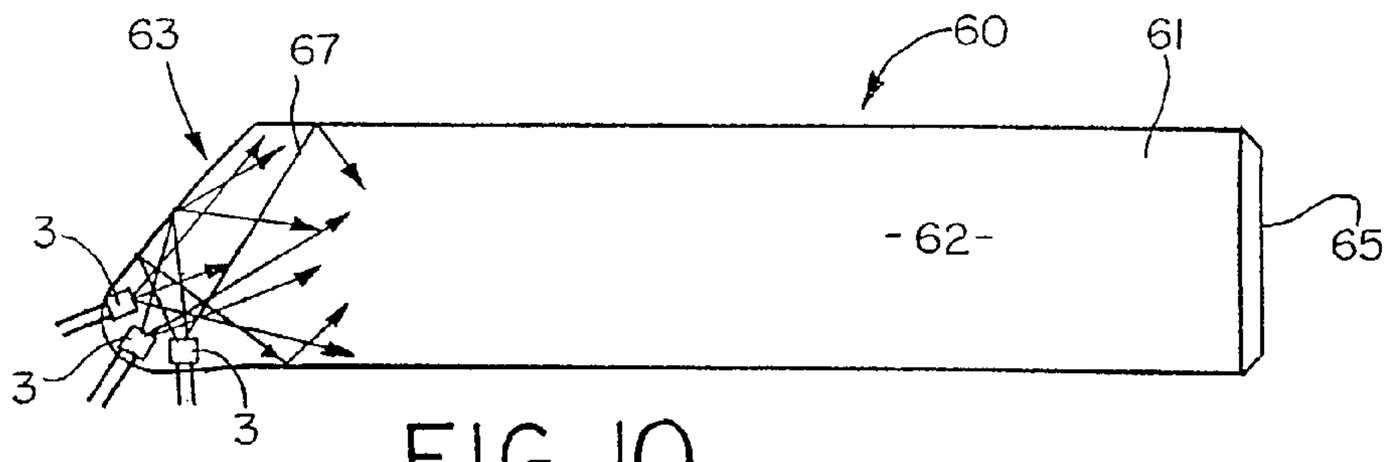

FIG. 10

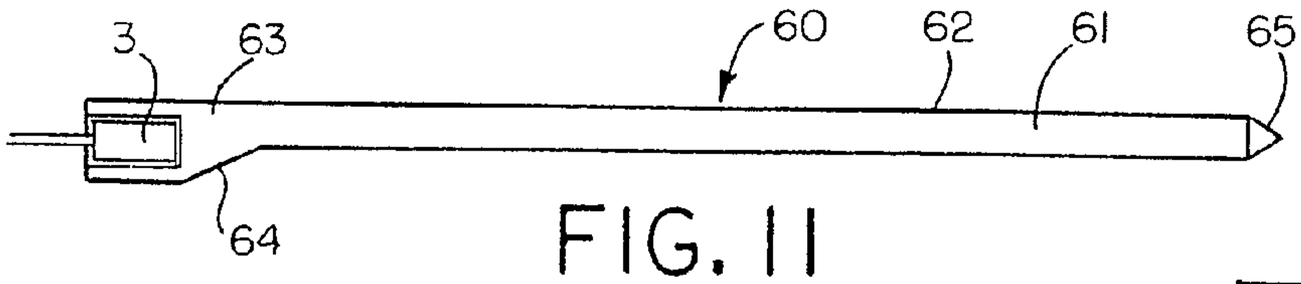

FIG. 11

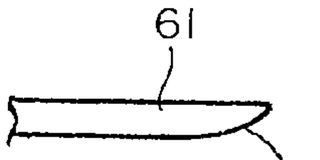

FIG. 11a

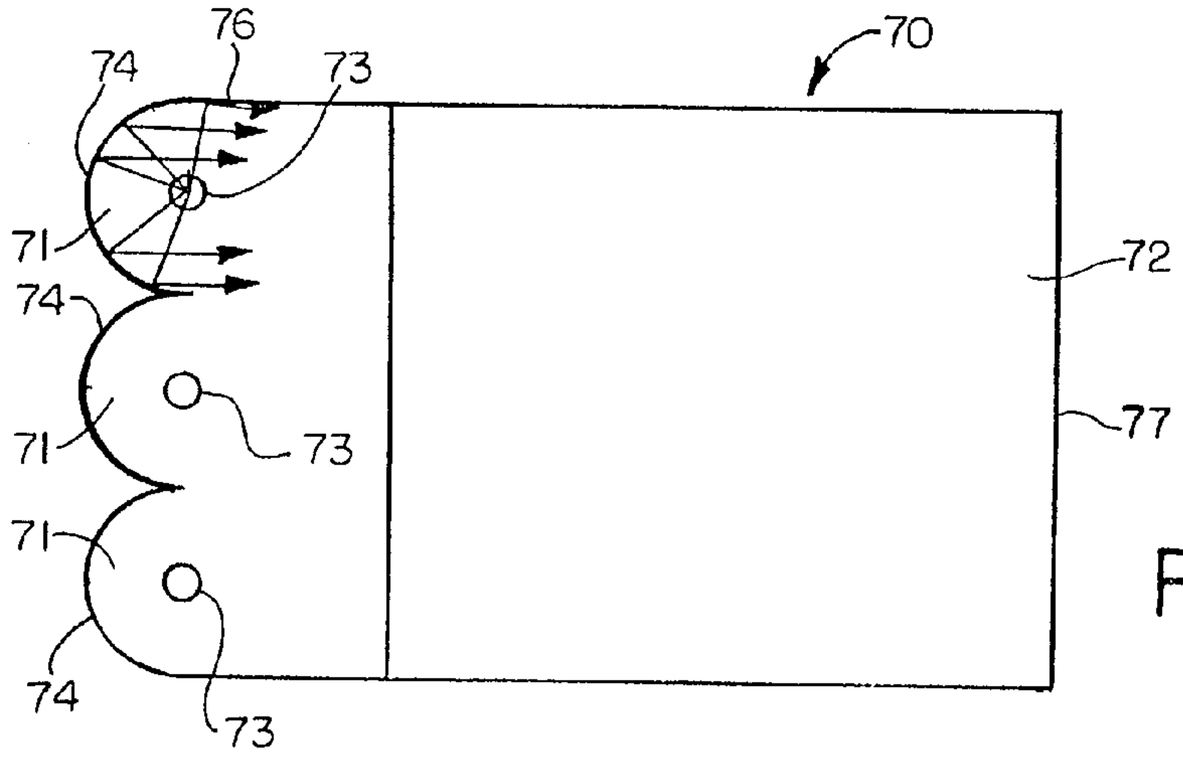

FIG. 12

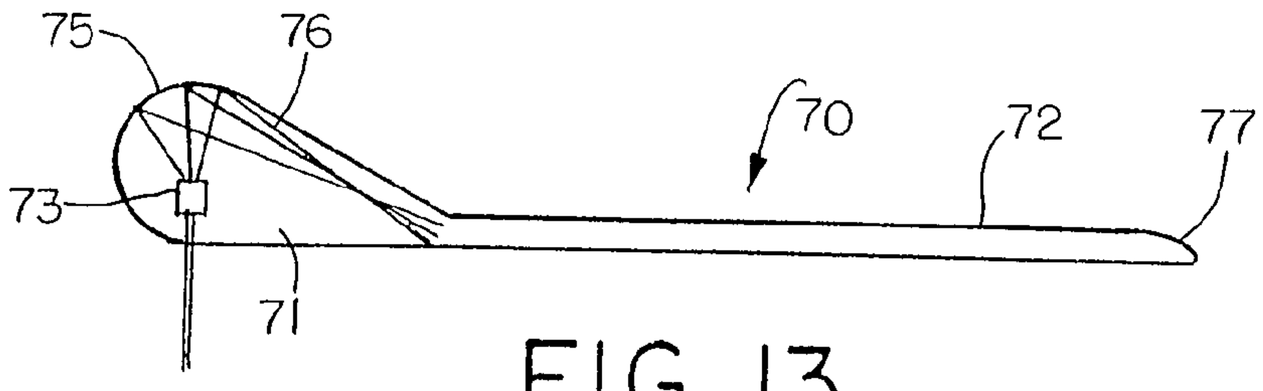

FIG. 13

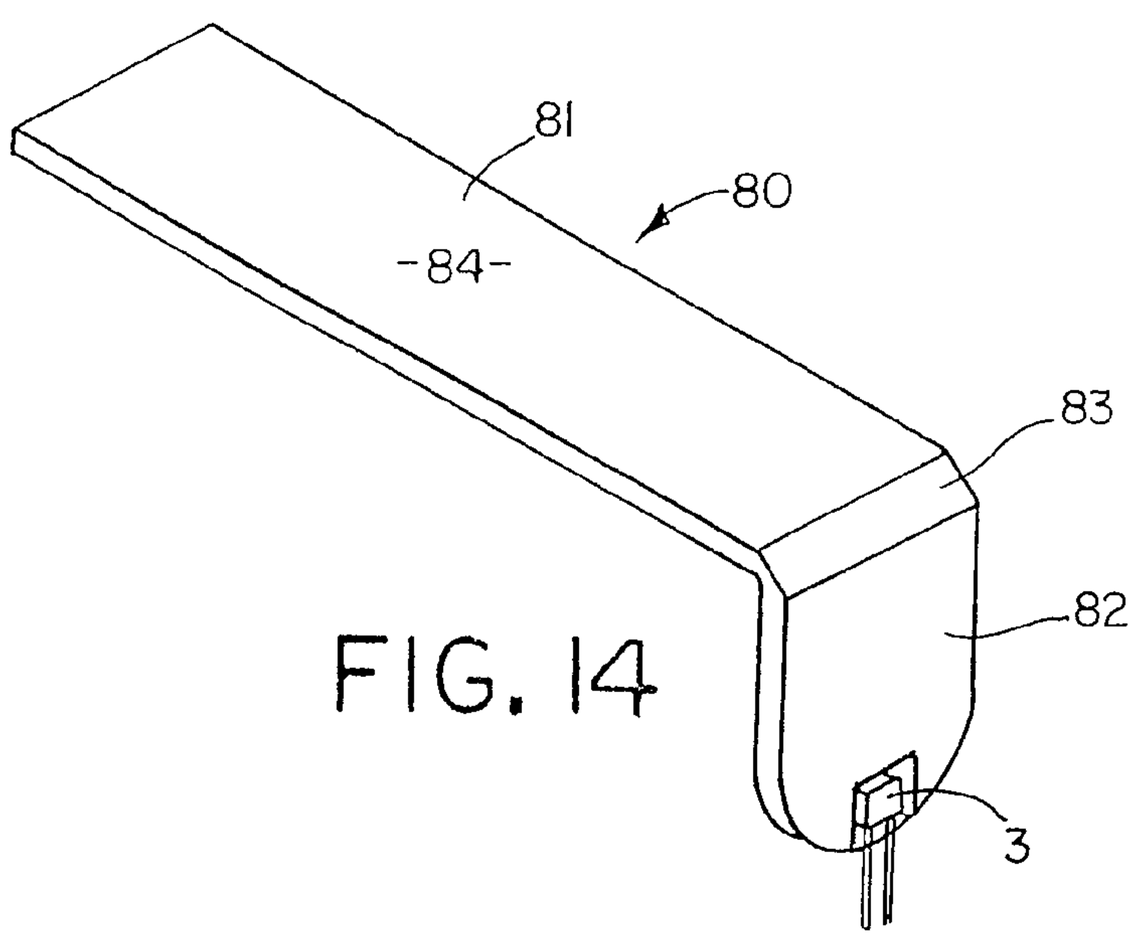

FIG. 14

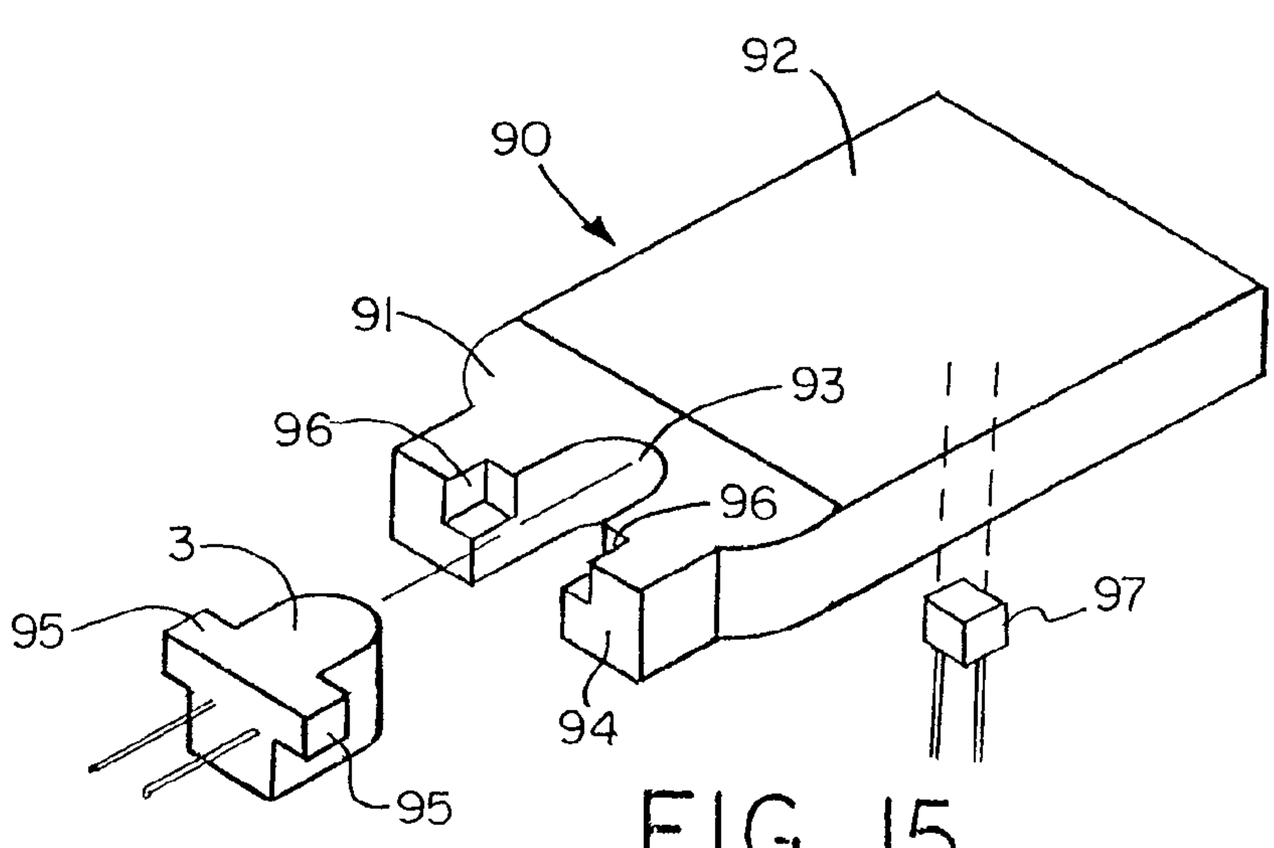

FIG. 15

LIGHT EMITTING PANEL ASSEMBLIES

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 12/940,424, filed Nov. 5, 2010, which is a continuation of U.S. patent application Ser. No. 12/488,617, filed Jun. 22, 2009, now abandoned, which is a continuation of U.S. patent application Ser. No. 12/246,613, filed Oct. 7, 2008, now abandoned, which is a division of U.S. patent application Ser. No. 11/504,203, filed Aug. 15, 2006, now U.S. Pat. No. 7,467,887, dated Dec. 23, 2008, which is a continuation of U.S. patent application Ser. No. 10/784,527, filed Feb. 23, 2004, now U.S. Pat. No. 7,160,015, dated Jan. 9, 2007, which is a division of U.S. patent application Ser. No. 09/256,275, filed Feb. 23, 1999, now U.S. Pat. No. 6,712,481, dated Mar. 30, 2004, which is a continuation-in-part of U.S. patent application Ser. No. 08/778,089, filed Jan. 2, 1997, now U.S. Pat. No. 6,079,838, dated Jun. 27, 2000, which is a division of U.S. patent application Ser. No. 08/495,176, filed Jun. 27, 1995, now U.S. Pat. No. 5,613,751, dated Mar. 25, 1997.

BACKGROUND OF THE INVENTION

This invention relates generally, as indicated, to light emitting panel assemblies each including a transparent panel member for efficiently conducting light, and controlling the light conducted by the panel member to be emitted from one or more light output areas along the length thereof.

Light emitting panel assemblies are generally known. However, the present invention relates to several different light emitting panel assembly configurations which provide for better control of the light output from the panel assemblies and for more efficient utilization of light, which results in greater light output from the panel assemblies.

SUMMARY OF THE INVENTION

In accordance with one aspect of the invention, the light emitting panel assemblies include a light emitting panel member having a light transition area in which at least one light source is suitably mounted for transmission of light to the light input surface of the panel member.

In accordance with another aspect of the invention, the light source is desirably embedded, potted or bonded to the light transition area to eliminate any air gaps, decrease surface reflections and/or eliminate any lens effect between the light source and light transition area, thereby reducing light loss and increasing the light output from the panel assembly.

In accordance with another aspect of the invention, the panel assemblies may include reflective or refractive surfaces for changing the path of a portion of the light, emitted from the light source, that would not normally enter the panel members at an acceptable angle that allows the light to remain in the panel members for a longer period of time and/or increase the efficiency of the panel members.

In accordance with another aspect of the invention, the light emitting panel members include a pattern of light extracting deformities or disruptions which provide a desired light output distribution from the panel members by changing the angle of refraction of a portion of the light from one or more light output areas of the panel members.

In accordance with still another aspect of the invention, the light source may include multiple colored light sources for

supplying light to one or more light output areas, and for providing a colored or white light output distribution.

In accordance with yet another aspect of the invention, the panel assemblies include a transition area for mixing the multiple colored lights, prior to the light entering the panel members, in order to effect a desired colored or white light output distribution.

The various light emitting panel assemblies of the present invention are very efficient panel assemblies that may be used to produce increased uniformity and higher light output from the panel members with lower power requirements, and allow the panel members to be made thinner and/or longer, and/or of various shapes and sizes.

To the accomplishment of the foregoing and related ends, the invention then comprises the features hereinafter fully described and particularly pointed out in the claims, the following description and the annexed drawings setting forth in detail certain illustrative embodiments of the invention, these being indicative, however, of but several of the various ways in which the principles of the invention may be employed.

BRIEF DESCRIPTION OF THE DRAWINGS

In the annexed drawings:

FIGS. **1** through **3** are schematic perspective views of three different forms of light emitting panel assemblies in accordance with this invention;

FIG. **4***a* is an enlarged plan view of a portion of a light output area of a panel assembly showing one form of pattern of light extracting deformities on the light output area;

FIGS. **4***b, c* and *d* are enlarged schematic perspective views of a portion of a light output area of a panel assembly showing other forms of light extracting deformities formed in or on the light output area;

FIG. **5** is an enlarged transverse section through the light emitting panel assembly of FIG. **3** taken generally on the plane of the line **5-5** thereof;

FIG. **6** is a schematic perspective view of another form of light emitting panel assembly in accordance with this invention;

FIG. **7** is a schematic top plan view of another form of light emitting panel assembly in accordance with this invention;

FIG. **8** is a schematic perspective view of another form of light emitting panel assembly in accordance with this invention;

FIG. **9** is a schematic top plan view of another form of light emitting panel assembly in accordance with this invention;

FIG. **10** is a schematic top plan view of still another form of light emitting panel assembly in accordance with this invention;

FIG. **11** is a side elevation view of the light emitting panel assembly of FIG. **10**;

FIG. **11***a* is a fragmentary side elevation view showing a tapered or rounded end on the panel member in place of the prismatic surface shown in FIGS. **10** and **11**;

FIG. **12** is a schematic top plan view of another form of light emitting panel assembly in accordance with this invention;

FIG. **13** is a schematic side elevation view of the light emitting panel assembly of FIG. **12**; and

FIGS. **14** and **15** are schematic perspective views of still other forms of light emitting panel assemblies in accordance with this invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now in detail to the drawings, and initially to FIG. **1**, there is schematically shown one form of light emit-

ting panel assembly **1** in accordance with this invention including a transparent light emitting panel **2** and one or more light sources **3** which emit light in a predetermined pattern in a light transition member or area **4** used to make the transition from the light source **3** to the light emitting panel **2**, as well known in the art. The light that is transmitted by the light transition area **4** to the transparent light emitting panel **2** may be emitted along the entire length of the panel or from one or more light output areas along the length of the panel as desired to produce a desired light output distribution to fit a particular application.

In FIG. **1** the light transition area **4** is shown as an integral extension of one end of the light emitting panel **2** and as being generally rectangular in shape. However, the light transition area may be of other shapes suitable for embedding, potting, bonding or otherwise mounting the light source. Also, reflective or refractive surfaces may be provided to increase efficiency. Moreover, the light transition area **4** may be a separate piece suitably attached to the light input surface **13** of the panel member if desired. Also, the sides of the light transition area may be curved to more efficiently reflect or refract a portion of the light emitted from the light source through the light emitting panel at an acceptable angle.

FIG. **2** shows another form of light emitting panel assembly **5** in accordance with this invention including a panel light transition area **6** at one end of the light emitting panel **7** with sides **8**, **9** around and behind the light source **3** shaped to more efficiently reflect and/or refract and focus the light emitted from the light source **3** that impinges on these surfaces back through the light transition area **6** at an acceptable angle for entering the light input surface **18** at one end of the light emitting panel **7**. Also, a suitable reflective material or coating **10** may be provided on the portions of the sides of the light transition areas of the panel assemblies of FIGS. **1** and **2** on which a portion of the light impinges for maximizing the amount of light or otherwise changing the light that is reflected back through the light transition areas and into the light emitting panels.

The panel assemblies shown in FIGS. **1** and **2** include a single light source **3**, whereas FIG. **3** shows another light emitting panel assembly **11** in accordance with this invention including two light sources **3**. Of course, it will be appreciated that the panel assemblies of the present invention may be provided with any number of light sources as desired, depending on the particular application.

The panel assembly **11** of FIG. **3** includes a light transition area **12** at one end of the light emitting panel **14** having reflective and/or refractive surfaces **15** around and behind each light source **3**. These surfaces **15** may be appropriately shaped including for example curved, straight and/or faceted surfaces, and if desired, suitable reflective materials or coatings may be provided on portions of these surfaces to more efficiently reflect and/or refract and focus a portion of the light emitted for example from an incandescent light source which emits light in a 360° pattern through the light transition areas **12** into the light input surface **19** of the light emitting panel **14**.

The light sources **3** may be mechanically held in any suitable manner in slots, cavities or openings **16** machined, molded or otherwise formed in the light transition areas of the panel assemblies. However, preferably the light sources **3** are embedded, potted or bonded in the light transition areas in order to eliminate any air gaps or air interface surfaces between the light sources and surrounding light transition areas, thereby reducing light loss and increasing the light output emitted by the light emitting panels. Such mounting of the light sources may be accomplished, for example, by bonding the light sources **3** in the slots, cavities or openings **16** in the light transition areas using a sufficient quantity of a suitable embedding, potting or bonding material **17**. The slots, cavities or openings **16** may be on the top, bottom, sides or back of the light transition areas. Bonding can also be accomplished by a variety of methods that do not incorporate extra material, for example, thermal bonding, heat staking, ultrasonic or plastic welding or the like. Other methods of bonding include insert molding and casting around the light source(s).

A transparent light emitting material of any suitable type, for example acrylic or polycarbonate, may be used for the light emitting panels. Also, the panels may be substantially flat, or curved, may be a single layer or multi-layers, and may have different thicknesses and shapes. Moreover, the panels may be flexible, or rigid, and may be made out of a variety of compounds. Further, the panels may be hollow, filled with liquid, air, or be solid, and may have holes or ridges in the panels.

Each light source **3** may also be of any suitable type including, for example, any of the types disclosed in U.S. Pat. Nos. 4,897,771 and 5,005,108, assigned to the same assignee as the present application, the entire disclosures of which are incorporated herein by reference. In particular, the light sources **3** may be an arc lamp, an incandescent bulb which also may be colored, filtered or painted, a lens end bulb, a line light, a halogen lamp, a light emitting diode (LED), a chip from an LED, a neon bulb, a fluorescent tube, a fiber optic light pipe transmitting from a remote source, a laser or laser diode, or any other suitable light source. Additionally, the light sources **3** may be a multiple colored LED, or a combination of multiple colored radiation sources in order to provide a desired colored or white light output distribution. For example, a plurality of colored lights such as LEDs of different colors (red, blue, green) or a single LED with multiple colored chips may be employed to create white light or any other colored light output distribution by varying the intensities of each individual colored light.

A pattern of light extracting deformities or disruptions may be provided on one or both sides of the panel members or on one or more selected areas on one or both sides of the panel members, as desired. FIG. **4***a* schematically shows one such light surface area **20** on which a pattern of light extracting deformities or disruptions **21** is provided. As used herein, the term deformities or disruptions are used interchangeably to mean any change in the shape or geometry of the panel surface and/or coating or surface treatment that causes a portion of the light to be emitted. The pattern of light extracting deformities **21** shown in FIG. **4***a* includes a variable pattern which breaks up the light rays such that the internal angle of reflection of a portion of the light rays will be great enough to cause the light rays either to be emitted out of the panel through the side or sides on which the light extracting deformities **21** are provided or reflected back through the panel and emitted out the other side.

These deformities or disruptions **21** can be produced in a variety of manners, for example, by providing a painted pattern, an etched pattern, a machined pattern, a printed pattern, a hot stamped pattern, or a molded pattern or the like on selected light output areas of the panel members. An ink or printed pattern may be applied for example by pad printing, silk screening, ink jet, heat transfer film process or the like. The deformities may also be printed on a sheet or film which is used to apply the deformities to the panel member. This sheet or film may become a permanent part of the light panel assembly for example by attaching or otherwise positioning

the sheet or film against one or both sides of the panel member similar to the sheet or film **27** shown in FIGS. **3** and **5** in order to produce a desired effect.

By varying the density, opaqueness or translucence, shape, depth, color, area, index of refraction, or type of deformities **21** on an area or areas of the panels, the light output of the panels can be controlled. The deformities or disruptions may be used to control the percent of light emitted from any area of the panels. For example, less and/or smaller size deformities **21** may be placed on panel areas where less light output is wanted. Conversely, a greater percentage of and/or larger deformities may be placed on areas of the panels where greater light output is desired.

Varying the percentages and/or size of deformities in different areas of the panel is necessary in order to provide a uniform light output distribution. For example, the amount of light traveling through the panels will ordinarily be greater in areas closer to the light source than in other areas further removed from the light source. A pattern of light extracting deformities **21** may be used to adjust for the light variances within the panel members, for example, by providing a denser concentration of light extracting deformities with increased distance from the light source **3** thereby resulting in a more uniform light output distribution from the light emitting panels.

The deformities **21** may also be used to control the output ray angle distribution of the emitted light to suit a particular application. For example, if the panel assemblies are used to provide a liquid crystal display backlight, the light output will be more efficient if the deformities **21** cause the light rays to emit from the panels at predetermined ray angles such that they will pass through the liquid crystal display with low loss.

Additionally, the pattern of light extracting deformities may be used to adjust for light output variances attributed to light extractions of the panel members. The pattern of light extracting deformities **21** may be printed on the light output areas utilizing a wide spectrum of paints, inks, coatings, epoxies, or the like, ranging from glossy to opaque or both, and may employ half-tone separation techniques to vary the deformity **21** coverage. Moreover, the pattern of light extracting deformities **21** may be multiple layers or vary in index of refraction.

Print patterns of light extracting deformities **21** may vary in shapes such as dots, squares, diamonds, ellipses, stars, random shapes, and the like, and are desirably 0.006 square inch per deformity/element or less. Also, print patterns that are 60 lines per inch or finer are desirably employed, thus making the deformities or shapes **21** in the print patterns nearly invisible to the human eye in a particular application thereby eliminating the detection of gradient or banding lines that are common to light extracting patterns utilizing larger elements. Additionally, the deformities may vary in shape and/or size along the length and/or width of the panel members. Also, a random placement pattern of the deformities may be utilized throughout the length and/or width of the panel members. The deformities may have shapes or a pattern with no specific angles to reduce moiré or other interference effects. Examples of methods to create these random patterns are printing a pattern of shapes using stochastic print pattern techniques, frequency modulated half tone patterns, or random dot half tones. Moreover, the deformities may be colored in order to effect color correction in the panel members. The color of the deformities may also vary throughout the panel members, for example to provide different colors for the same or different light output areas.

In addition to or in lieu of the patterns of light extracting deformities **21** shown in FIG. **4***a*, other light extracting deformities including prismatic surfaces, depressions or raised surfaces of various shapes using more complex shapes in a mold pattern may be molded, etched, stamped, thermoformed, hot stamped or the like into or on one or more areas of the panel member. FIGS. **4***b* and **4***c* show panel areas **22** on which prismatic surfaces **23** or depressions **24** are formed in the panel areas, whereas FIG. **4***d* shows prismatic or other reflective or refractive surfaces **25** formed on the exterior of the panel area. The prismatic surfaces, depressions or raised surfaces will cause a portion of the light rays contacted thereby to be emitted from the panel member. Also, the angles of the prisms, depressions or other surfaces may be varied to direct the light in different directions to produce a desired light output distribution or effect. Moreover, the reflective or refractive surfaces may have shapes or a pattern with no specific angles to reduce moiré or other interference effects.

As best seen in the cross sectional view of FIG. **5**, a back reflector (including trans reflectors) **26** may be attached or positioned against one side of the panel member **14** of FIG. **3** using a suitable adhesive **28** or other method in order to improve light output efficiency of the panel assembly **11** by reflecting the light emitted from that side back through the panel for emission through the opposite side. Additionally, a pattern of light extracting deformities **21**, **23**, **24** and/or **25** may be provided on one or both sides of the panel member in order to change the path of the light so that the internal critical angle is exceeded and a portion of the light is emitted from one or both sides of the panel. Moreover, a transparent film, sheet or plate **27** may be attached or positioned against the side or sides of the panel member from which light is emitted using a suitable adhesive **28** or other method in order to produce a desired effect.

The member **27** may be used to further improve the uniformity of the light output distribution. For example, the member **27** may be a colored film, a diffuser, or a label or display, a portion of which may be a transparent overlay that may be colored and/or have text or an image thereon.

If adhesive **28** is used to adhere the back reflector **26** and/or film **27** to the panel, the adhesive is preferably applied only along the side edges of the panel, and if desired the end edge opposite the light transition areas **12**, but not over the entire surface area or areas of the panel because of the difficulty in consistently applying a uniform coating of adhesive to the panel. Also, the adhesive changes the internal critical angle of the light in a less controllable manner than the air gaps **30** (see FIG. **5**) which are formed between the respective panel surfaces and the back reflector **26** and/or film **27** when only adhered along the peripheral edges. Additionally, longer panel members are achievable when air gaps **30** are used. If adhesive were to be used over the entire surface, the pattern of deformities could be adjusted to account for the additional attenuation in the light caused by the adhesive.

Referring further to FIG. **2**, the panel assembly **5** shown therein also includes molded posts **31** at one or more corners of the panel **7** (four such posts being shown) which may be used to facilitate mounting of the panel assembly and providing structural support for other parts or components, for example, a display panel such as a liquid crystal display panel as desired.

FIG. **6** shows another form of light emitting panel assembly **32** in accordance with this invention including a panel member **33**, one or more light sources **3**, and one or more light output areas **34**. In addition, the panel assembly **32** includes a tray **35** having a cavity or recess **36** in which the panel assembly **32** is received. The tray **35** may act as a back reflector as well as end edge and/or side edge reflectors for the panel **33** and side and/or back reflectors **37** for the light sources **3**.

Additionally, one or more secondary reflective or refractive surfaces **38** may be provided on the panel member **33** and/or tray **35** to reflect a portion of the light around one or more corners or curves in a non-rectangular shaped panel member **33**. These secondary reflective/refractive surfaces **38** may be flat, angled, faceted or curved, and may be used to extract a portion of the light away from the panel member in a predetermined pattern. FIG. **6** also shows multiple light output areas **34** on the panel member that emit light from one or more light sources **3**.

FIG. **7** is a schematic illustration of still another form of light emitting panel assembly **40** in accordance with this invention including a panel member **41** having one or more light output areas **42** and one or more light transition areas (mixing areas) **43** containing a plurality of light sources **3** at one or both ends of the panel. Each transition area mixes the light from one or more light sources having different colors and/or intensities. In this particular embodiment, each of the light sources **3** desirably employs three colored LEDs (red, blue, green) in each transition mixing area **43** so that the light from the three LEDs can be mixed to produce a desired light output color that will be emitted from the light output area **42**. Alternatively, each light source may be a single LED having multiple colored chips bonded to the lead film. Also, two colored LEDs or a single LED having two colored chips may be used for a particular application. By varying the intensities of the individual respective LEDs, virtually any colored light output or white light distribution can be achieved.

FIG. **8** shows yet another form of light emitting panel assembly **45** in accordance with this invention including a light emitting panel member **46** and a light source **3** in a light transition area **48** integral with one end of the panel member. In this particular embodiment, the panel member **46** is three-dimensionally curved, for example, such that light rays may be emitted in a manner that facilitates aesthetic design of a lighted display.

FIG. **9** schematically shows another form of light emitting panel assembly **50** in accordance with this invention, including a panel member **51** having multiple light output areas **52**, and mounting posts and/or mounting tabs **53**. This particular panel assembly **50** may serve as a structural member to support other parts or components as by providing holes or cavities **54**, **55** in the panel member **51** which allow for the insertion of modular components or other parts into the panel member. Moreover, a separate cavity or recess **56** may be provided in the panel member **51** for receipt of a correspondingly shaped light transition area **57** having one or more light sources **3** embedded, bonded, cast, insert molded, epoxied, or otherwise mounted or positioned therein and a curved reflective or refractive surface **58** on the transition area **57** and/or wall of the cavity or recess **56** to redirect a portion of the light in a predetermined manner. In this way the light transition area **57** and/or panel member may be in the form of a separate insert which facilitates the easy placement of the light source in a modular manner. A reflector **58** may be placed on the reflective or refractive surface of the cavity or recess **56** or insert **57**. Where the reflector **58** is placed on the reflective or refractive surface of the cavity or recess **56**, the cavity or recess may act as a mold permitting transparent material from which the transition area **57** is made to be cast around one or more light sources **3**.

FIGS. **10** and **11** schematically show another form of light emitting panel assembly **60** in accordance with this invention including a panel member **61** having one or more light output areas **62**. In this particular embodiment, an off-axis light transition area **63** is provided that is thicker in cross section than the panel member to permit use of one or more light

sources **3** embedded or otherwise mounted in the light transition area that are dimensionally thicker than the panel member. Also, a three-dimensional reflective surface **64** (FIG. **11**) may be provided on the transition area **63**. Moreover, a prism **65** (FIG. **11**) or tapered, rounded, or otherwise shaped end **66** (FIG. **11***a*) may be provided at the end of the panel opposite the light sources **3** to perform the function of an end reflector. The light sources **3** may be oriented at different angles relative to each other and offset to facilitate better mixing of the light rays **67** in the transition area **63** as schematically shown in FIG. **10** and/or to permit a shorter length transition area **63** to be used.

FIGS. **12** and **13** schematically show still another form of light emitting panel assembly **70** in accordance with this invention which includes one or more light transition areas **71** at one or both ends of the panel member **72** each containing a single light source **73**. The transition area or areas **71** shown in FIGS. **12** and **13** collect light with multiple or three-dimensional surfaces and/or collect light in more than one plane. For example each transition area **71** shown in FIGS. **12** and **13** has elliptical and parabolic shape surfaces **74** and **75** in different planes for directing the light rays **76** into the panel member at a desired angle.

Providing one or more transition areas at one or both ends of the panel member of any desired dimension to accommodate one or more light sources, with reflective and/or refractive surfaces on the transition areas for redirecting the light rays into the panel member at relatively low angles allows the light emitting panel member to be made much longer and thinner than would otherwise be possible. For example the panel members of the present invention may be made very thin, i.e., 0.125 inch thick or less.

FIG. **14** schematically illustrates still another form of light emitting panel assembly **80** in accordance with this invention including a light emitting panel **81** and one or more light sources **3** positioned, embedded, potted, bonded or otherwise mounted in a light transition area **82** that is at an angle relative to the panel member **81** to permit more efficient use of space. An angled or curved reflective or refractive surface **83** is provided at the junction of the panel member **81** with the transition area **82** in order to reflect/refract light from the light source **3** into the body of the panel member **81** for emission of light from one or more light emitting areas **84** along the length of the panel member.

FIG. **15** schematically illustrates still another form of light emitting panel assembly **90** in accordance with this invention including a light transition area **91** at one or both ends of a light emitting panel member **92** containing a slot **93** for sliding receipt of an LED or other suitable light source **3**. Preferably the slot **93** extends into the transition area **91** from the back edge **94**, whereby the light source **3** may be slid and/or snapped in place in the slot from the back, thus allowing the transition area to be made shorter and/or thinner. The light source **3** may be provided with wings, tabs or other surfaces **95** for engagement in correspondingly shaped recesses or grooves **96** or the like in the transition area **91** for locating and, if desired, securing the light source in place. Also, the light source **3** may be embedded, potted, bonded or otherwise secured within the slot **93** in the light transition area **91** of the panel member **92**. Light from a secondary light source **97** may be projected through the panel member **92** for indication or some other effect.

The various light emitting panel assemblies disclosed herein may be used for a great many different applications including for example LCD back lighting or lighting in general, decorative and display lighting, automotive lighting, dental lighting, phototherapy or other medical lighting, mem-

brane switch lighting, and sporting goods and apparel lighting or the like. Also the panel assemblies may be made such that the panel members and deformities are transparent without a back reflector. This allows the panel assemblies to be used for example to front light an LCD or other display such that the display is viewed through the transparent panel members.

Although the invention has been shown and described with respect to certain preferred embodiments, it is obvious that equivalent alterations and modifications will occur to others skilled in the art upon the reading and understanding of the specification. The present invention includes all such equivalent alterations and modifications, and is limited only by the scope of the claims.

What is claimed is:

1. A light emitting assembly comprising at least one light source, a light emitting panel member having at least one input edge for receiving light from the light source and a light emitting surface, a tray or housing having a cavity or recess in which the panel member is entirely received, wherein the panel member has a pattern of light extracting deformities on or in at least one surface to cause light to be emitted from the light emitting surface of the panel member, end edge reflectors and side edge reflectors, and an additional component overlying the panel member, wherein the panel member has a greater width than height, and the light input edge has a refractive surface that redirects the light output distribution of the light source more in the width direction as the light enters the panel member.

2. The assembly of claim **1**, wherein the end edge reflectors and the side edge reflectors are on end edges and side edges of the panel member.

3. The assembly of claim **1**, wherein the end edge reflectors and the side edge reflectors are on end walls and side walls of the tray or housing.

4. The assembly of claim **1**, wherein the light source comprises one or more LEDs.

* * * * *

EXHIBIT 2

Style Definition: List Number 2: Tab stops: Not at 1.25"

IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF DELAWARE

DELAWARE DISPLAY GROUP LLC and INNOVATIVE DISPLAY TECHNOLOGIES LLC,	§	
	§	**C.A. No. 13-cv-2109-RGA**
Plaintiffs,	§	**JURY TRIAL DEMANDED**
v.	§	**FILED UNDER SEAL**
LG ELECTRONICS, INC., LG ELECTRONICS U.S.A., INC., LG DISPLAY CO., LTD., and LG DISPLAY AMERICA, INC.,	§	
Defendants.	§	

PLAINTIFFS' ~~FIRST~~SECOND AMENDED COMPLAINT

Delaware Display Group LLC and Innovative Display Technologies LLC (collectively, "Plaintiffs") by and through their undersigned counsel, file this ~~First~~Second Amended Complaint against LG Electronics, Inc.; LG Electronics U.S.A., Inc.; LG Display Co., Ltd.; and LG Display America, Inc. (collectively, "LG")

THE PARTIES

1. Delaware Display Group LLC ("DDG") is a Delaware limited liability company with its principal place of business located at 2400 Dallas Parkway, Suite 200, Plano, Texas 75093.

2. Innovative Display Technologies LLC ("IDT") is a Texas limited liability company with its principal place of business located at 2400 Dallas Parkway, Suite 200, Plano, Texas 75093.

3. Upon information and belief, LG Electronics, Inc. ("LG Electronics") is a corporation in South Korea located at LG Twin Towers, 20, Yeouido-dong, Yeongdeungpo-gu, Seoul, 150-721, South Korea. Upon information and belief, LG Electronics may be served with

process in South Korea pursuant to the Hague Convention on the Service Abroad of Judicial and Extrajudicial Documents in Civil or Commercial Matters.

4. Upon information and belief, LG Electronics U.S.A., Inc. ("LG Electronics U.S.A.") is a Delaware Corporation with offices at 1000 Sylvan Avenue, Englewood Cliffs, New Jersey 07632. Upon information and belief, LG Electronics U.S.A. may be served with process by serving its registered agent, United States Corporation Company, 2711 Centerville Road, Suite 400, Wilmington, Delaware 19808. Upon information and belief, LG Electronics U.S.A. is a subsidiary of LG Electronics.

5. Upon information and belief, LG Display Co., Ltd. ("LG Display") is a corporation in South Korea located at LG U+ Bldg., Hangang-ro 3-ga, Yongsan-gu, Seoul, Korea. Upon information and belief, LG Display may be served with process in South Korea pursuant to the Hague Convention on the Service Abroad of Judicial and Extrajudicial Documents in Civil or Commercial Matters. Upon information and belief, LG Display is a subsidiary of LG Electronics.

6. Upon information and belief, LG Display America, Inc. ("LG Display America") is a California Corporation with its principal place of business at 2540 North First Street, Suite 400, San Jose, California 95131. Upon information and belief, LG Display America may be served with process by serving its Agent for Service, Dong Hoon Han, LG Display America, Inc., 2540 North First Street, Suite 400, San Jose, California 95131. Upon information and belief, LG Display America is a subsidiary of LG Display.

7. Upon information and belief, LG has conducted and regularly conducts business within this District, has purposefully availed itself of the privileges of conducting business in this District, and has sought protection and benefit from the laws of the State of Delaware.

JURISDICTION AND VENUE

8. This action arises under the Patent Laws of the United States, 35 U.S.C. § 1, *et seq.*, including 35 U.S.C. §§ 271, 281, 283, 284, and 285. This Court has subject matter jurisdiction over this case for patent infringement under 28 U.S.C. §§ 1331 and 1338(a).

9. As further detailed herein, this Court has personal jurisdiction over LG. LG is amenable to service of summons for this action. Furthermore, personal jurisdiction over LG in this action comports with due process. LG has conducted and regularly conducts business within the United States and this District. LG has purposefully availed itself of the privileges of conducting business in the United States and, more specifically, in this District. LG has sought protection and benefit from the laws of the State of Delaware by incorporating in the state of Delaware, incorporating a subsidiary in the State of Delaware, and/or by placing infringing products into the stream of commerce through an established distribution channel with the expectation and/or knowledge that they will be purchased by consumers in this District. Plaintiffs' causes of action arise directly from LG's business contacts and other activities in this District.

10. LG – directly or through intermediaries (including distributors, retailers, and others), subsidiaries, alter egos, and/or agents – ships, distributes, offers for sale, and/or sells its products in the United States and this District. LG has purposefully and voluntarily placed one or more of its infringing products, as described below, into the stream of commerce with the expectation and/or knowledge that they will be purchased by consumers in this District. LG knowingly and purposefully ships infringing products into and within this District through an established distribution channel. These infringing products have been and continue to be purchased by consumers in this District. Upon information and belief, LG has committed the tort of patent infringement in this District and/or has induced others to commit patent infringement in this District.

11. Venue is proper in this Court under 28 U.S.C. §§ 1391(b), (c), and (d), as well as 28 U.S.C. § 1400(b), in that LG is subject to personal jurisdiction in this District, and therefore is deemed to reside in this District for purposes of venue, and, upon information and belief, LG has committed acts within this judicial District giving rise to this action and does business in this District, including but not limited to making sales in this District, providing service and support to their respective customers in this District, and/or operating an interactive website that is available to persons in this District, which website advertises, markets, and/or offers for sale infringing products.

BACKGROUND

A. The Patents-In-Suit.

~~12.~~ U.S. Patent No. ~~7,384,177 titled "Light Emitting Panel Assemblies" ("the '177 patent") was duly and legally issued by the U.S. Patent and Trademark Office on June 10, 2008, after full and fair examination. Jeffery R. Parker is the sole inventor listed on the '177 patent. A true and correct copy of the '177 patent is attached as **Exhibit A** and made a part hereof.~~

~~13. U.S. Patent No. 7,404,660 titled "Light Emitting Panel Assemblies" ("the '660 patent") was duly and legally issued by the U.S. Patent and Trademark Office on July 29, 2008, after full and fair examination. Jeffery R. Parker is the sole inventor listed on the '660 patent. A true and correct copy of the '660 patent is attached as **Exhibit B** and made a part hereof.~~

~~14.~~12. ~~U.S. Patent No. 7,434,973 titled "Light Emitting Panel Assemblies" ("the '973~~7,434,974 titled "Light Emitting Panel Assemblies" ("the '974 patent") was duly and legally issued by the U.S. Patent and Trademark Office on October 14, 2008, after full and fair examination. Jeffery R. Parker~~, Gregory A. Coghlan, and Robert M. Ezell are~~ is the ~~inventors~~sole inventor listed on the ~~'973~~'974 patent. ~~A~~ true and correct copy of the ~~'973~~'974 patent is attached as **Exhibit ~~C~~A** and made a part hereof.

~~15. U.S. Patent No. 7,434,974 titled "Light Emitting Panel Assemblies" ("the '974 patent") was duly and legally issued by the U.S. Patent and Trademark Office on October 14, 2008, after full and fair examination. Jeffery R. Parker is the sole inventor listed on the '974 patent. A true and correct copy of the '974 patent is attached as **Exhibit D** and made a part hereof.~~

~~16.~~13. U.S. Patent No. 7,537,370 titled "Light Emitting Panel Assemblies" ("the '370 patent") was duly and legally issued by the U.S. Patent and Trademark Office on May 26, 2009, after full and fair examination. Jeffery R. Parker is the sole inventor listed on the '370 patent. A true and correct copy of the '370 patent is attached as **Exhibit ~~E~~B** and made a part hereof.

~~17.~~14. U.S. Patent No. 7,914,196 titled "Light Redirecting Film Systems Having Pattern of Variable Optical Elements" ("the '196 patent") was duly and legally issued by the U.S. Patent and Trademark Office on March 29, 2011, after full and fair examination. Jeffery R. Parker, Timothy A. McCollum, and Robert M. Ezell are the inventors listed on the '196 patent. A true and correct copy of the '196 patent is attached as **Exhibit ~~F~~C** and made a part hereof.

~~18.~~15. U.S. Patent No. 8,215,816 titled "Light Emitting Panel Assemblies" ("the '816 patent") was duly and legally issued by the U.S. Patent and Trademark Office on July 10, 2012, after full and fair examination. Jeffery R. Parker is the sole inventor listed on the '816 patent. A true and correct copy of the '816 patent is attached as **Exhibit ~~G~~D** and made a part hereof.

~~19.~~16. The ~~'973 patent and the~~ '196 patent ~~are collectively~~is referred to as the "DDG ~~patents~~patent."

~~20.~~17. ~~The '177 patent, the '660 patent, the~~The '974 patent, the '370 patent, and the '816 patent are collectively referred to as the "IDT patents." Together, the "DDG ~~patents~~patent" and the "IDT patents" are the "patents-in-suit."

~~21.~~18. On June 26, 2013, IDT was assigned all of the right, title, and interest in the IDT patents, including the exclusive right to sue and collect for its own use and benefit all claims for damages by reason of past infringement or use of the IDT patents.

~~22.~~19. On December 20, 2013, DDG was assigned all of the right, title, and interest in the DDG patent, including the exclusive right to sue and collect for its own use and benefit all claims for damages by reason of past infringement or use of the DDG patent.

~~23.~~20. The patents-in-suit all share the same ultimate parent patent, U.S. Patent No. 5,613,751. The patents-in-suit share inventors, subject matter, and claim terms. The accused products infringe the Patents-in-Suit based on the use of the same technology, *i.e.*, backlights for LCD displays. And IDT and DDG share a common corporate parent.

B. LG's Infringing Conduct.

~~24.~~21. Upon information and belief, LG makes, uses, offers to sell, and/or sells within, and/or imports into the United States display products that use the fundamental technologies covered by the patents-in-suit. Upon information and belief, the infringing display products include, but are not limited to, mobile phones, tablets, televisions, and monitors with an LCD. By way of example only, Plaintiffs identify the Optimus E970 mobile phone as an infringing product of the patents-in-suit.

~~25.~~22. By incorporating the fundamental inventions covered by the patents-in-suit, LG can make improved products, including but not limited to, products with longer displays, thinner displays, and/or displays with a higher light output, a more uniform light output, a lower power requirement, and/or a longer battery life.

~~26.~~23. Upon information and belief, third-party distributors purchase and have purchased LG's infringing display products for sale or importation into the United States, including this

District. Upon information and belief, third-party consumers use and have used LG's infringing display products in the United States, including this District.

~~27.~~24. Upon information and belief, LG has purchased infringing display products that are made, used, offered for sale, sold within, and/or imported into the United States, including this District by third party manufacturers, distributors, and/or importers.

COUNT I

Patent Infringement of U.S. Patent No. 7,~~384,177~~434,974

~~28. Plaintiffs repeat and re-allege each and every allegation of paragraphs 1-27 as though fully set forth herein.~~

~~29. The '177 patent is valid and enforceable.~~

~~30. LG has never been licensed, either expressly or impliedly, under the '177 patent.~~

~~31. Upon information and belief, to the extent any marking or notice was required by 35 U.S.C. § 287, IDT has complied with the requirements of that statute by providing actual or constructive notice to LG of its alleged infringement. Upon information and belief, IDT surmises that any express licensees of the '177 patent have complied with the marking requirements of 35 U.S.C. § 287 by placing a notice of the '177 patent on all goods made, offered for sale, sold within, and/or imported into the United States that embody one or more claims of that patent.~~

~~32. Upon information and belief, LG has been and is directly infringing under 35 U.S.C. § 271(a), either literally or under the doctrine of equivalents, and/or indirectly infringing, by way of inducement with specific intent under 35 U.S.C. § 271(b), the '177 patent by making, using, offering to sell, and/or selling to third party distributors, and/or consumers (directly or through intermediaries and/or subsidiaries) in this District and elsewhere within the United States and/or importing into the United States, without authority, display products that include all of the limitations of one or more claims of the '177 patent, including but not limited to mobile phones,~~

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~~tablets, televisions, and monitors with an LCD, their display components, and/or other products made, used, sold, offered for sale, or imported by LG that include all of the limitations of one or more claims of the '177 patent.~~

~~33. Upon information and belief, distributors and consumers that purchase LG's display products that include all of the limitations of one or more claims of the '177 patent, including but not limited to mobile phones, tablets, televisions, and monitors with an LCD, also directly infringe, either literally or under the doctrine of equivalents, under 35 U.S.C. § 271(a), the '177 patent by using, offering to sell, and/or selling to third party distributors or consumers (directly or through intermediaries and/or subsidiaries) in this District and elsewhere within the United States and/or importing into the United States, those infringing display products.~~

~~34. Upon information and belief, the third party manufacturers, distributors, and importers that sell display products to LG that include all of the limitations of one or more claims of the '177 patent, also directly infringe, either literally or under the doctrine of equivalents, under 35 U.S.C. § 271(a), the '177 patent by making, offering to sell, and/or selling (directly or through intermediaries and/or subsidiaries) infringing products in this District and elsewhere within the United States and/or importing infringing products into the United States.~~

~~35. Upon information and belief, LG had knowledge of the '177 patent and its infringing conduct at least since the filing of this lawsuit, when LG was formally placed on notice of its infringement.~~

~~36. Upon information and belief, since at least the above-mentioned date when IDT formally placed LG on notice of its infringement, LG has actively induced, under U.S.C. § 271(b), third party manufacturers, distributors, importers and/or consumers that purchase or sell display products that include all of the limitations of one or more claims of the '177 patent, including but~~

not limited to mobile phones, tablets, televisions, and monitors with an LCD, to directly infringe one or more claims of the '177 patent. Since at least the notice provided on the above-mentioned date, LG does so with knowledge, or with willful blindness of the fact, that the induced acts constitute infringement of the '177 patent. Upon information and belief, LG intends to cause, and has taken affirmative steps to induce, infringement by these third-party manufacturers, distributors, importers, and/or consumers by, *inter alia*, creating advertisements that promote the infringing use of display products, creating established distribution channels for these products into and within the United States, purchasing these products, manufacturing these products in conformity with U.S. laws and regulations, distributing or making available instructions or manuals for these products to purchasers and prospective buyers, and/or providing technical support, replacement parts, or services for these products to these purchasers in the United States.

37. As a direct and proximate result of these acts of patent infringement, LG has encroached on the exclusive rights of IDT and its licensees to practice the '177 patent, for which IDT is entitled to at least a reasonable royalty.

COUNT II

Patent Infringement of U.S. Patent No. 7,404,660

38. Plaintiffs repeat and re-allege each and every allegation of paragraphs 1-37 as though fully set forth herein.

39. The '660 patent is valid and enforceable.

40. LG has never been licensed, either expressly or impliedly, under the '660 patent.

41. Upon information and belief, to the extent any marking or notice was required by 35 U.S.C. § 287, IDT has complied with the requirements of that statute by providing actual or constructive notice to LG of its alleged infringement. Upon information and belief, IDT surmises that any express licensees of the '660 patent have complied with the marking requirements of 35

~~U.S.C. § 287 by placing a notice of the '660 patent on all goods made, offered for sale, sold within, and/or imported into the United States that embody one or more claims of that patent.~~

~~42. Upon information and belief, LG has been and is directly infringing under 35 U.S.C. § 271(a), either literally or under the doctrine of equivalents, and/or indirectly infringing, by way of inducement with specific intent under 35 U.S.C. § 271(b), the '660 patent by making, using, offering to sell, and/or selling to third party distributors, and/or consumers (directly or through intermediaries and/or subsidiaries) in this District and elsewhere within the United States and/or importing into the United States, without authority, display products that include all of the limitations of one or more claims of the '660 patent, including but not limited to mobile phones, tablets, televisions, and monitors with an LCD, their display components, and/or other products made, used, sold, offered for sale, or imported by LG that include all of the limitations of one or more claims of the '660 patent.~~

~~43. Upon information and belief, distributors and consumers that purchase LG's display products that include all of the limitations of one or more claims of the '660 patent, including but not limited to mobile phones, tablets, televisions, and monitors with an LCD, also directly infringe, either literally or under the doctrine of equivalents, under 35 U.S.C. § 271(a), the '660 patent by using, offering to sell, and/or selling to third party distributors or consumers (directly or through intermediaries and/or subsidiaries) in this District and elsewhere within the United States and/or importing into the United States, those infringing display products.~~

~~44. Upon information and belief, the third party manufacturers, distributors, and importers that sell display products to LG that include all of the limitations of one or more claims of the '660 patent, also directly infringe, either literally or under the doctrine of equivalents, under 35 U.S.C. § 271(a), the '660 patent by making, offering to sell, and/or selling (directly or through~~

~~intermediaries and/or subsidiaries) infringing products in this District and elsewhere within the United States and/or importing infringing products into the United States.~~

~~45. Upon information and belief, LG had knowledge of the '660 patent and its infringing conduct at least since the filing of this lawsuit, when LG was formally placed on notice of its infringement.~~

~~46. Upon information and belief, since at least the above-mentioned date when IDT formally placed LG on notice of its infringement, LG has actively induced, under U.S.C. § 271(b), third party manufacturers, distributors, importers and/or consumers that purchase or sell display products that include all of the limitations of one or more claims of the '660 patent, including but not limited to mobile phones, tablets, televisions, and monitors with an LCD, to directly infringe one or more claims of the '660 patent. Since at least the notice provided on the above-mentioned date, LG does so with knowledge, or with willful blindness of the fact, that the induced acts constitute infringement of the '660 patent. Upon information and belief, LG intends to cause, and has taken affirmative steps to induce, infringement by these third-party manufacturers, distributors, importers, and/or consumers by, *inter alia*, creating advertisements that promote the infringing use of display products, creating established distribution channels for these products into and within the United States, purchasing these products, manufacturing these products in conformity with U.S. laws and regulations, distributing or making available instructions or manuals for these products to purchasers and prospective buyers, and/or providing technical support, replacement parts, or services for these products to these purchasers in the United States.~~

~~47. As a direct and proximate result of these acts of patent infringement, LG has encroached on the exclusive rights of IDT and its licensees to practice the '660 patent, for which IDT is entitled to at least a reasonable royalty.~~

COUNT III

Patent Infringement of U.S. Patent No. 7,434,973

48. Plaintiffs repeat and re-allege each and every allegation of paragraphs 1-47 as though fully set forth herein.

49. The '973 patent is valid and enforceable.

50. LG has never been licensed, either expressly or impliedly, under the '973 patent.

51. Upon information and belief, to the extent any marking or notice was required by 35 U.S.C. § 287, DDG has complied with the requirements of that statute by providing actual or constructive notice to LG of its alleged infringement. Upon information and belief, DDG surmises that any express licensees of the '973 patent have complied with the marking requirements of 35 U.S.C. § 287 by placing a notice of the '973 patent on all goods made, offered for sale, sold within, and/or imported into the United States that embody one or more claims of that patent.

52. Upon information and belief, LG has been and is directly infringing under 35 U.S.C. § 271(a), either literally or under the doctrine of equivalents, and/or indirectly infringing, by way of inducement with specific intent under 35 U.S.C. § 271(b), the '973 patent by making, using, offering to sell, and/or selling to third party distributors, and/or consumers (directly or through intermediaries and/or subsidiaries) in this District and elsewhere within the United States and/or importing into the United States, without authority, display products that include all of the limitations of one or more claims of the '973 patent, including but not limited to mobile phones, tablets, televisions, and monitors with an LCD, their display components, and/or other products made, used, sold, offered for sale, or imported by LG that include all of the limitations of one or more claims of the '973 patent.

53. Upon information and belief, distributors and consumers that purchase LG's display products that include all of the limitations of one or more claims of the '973 patent,

~~including but not limited to mobile phones, tablets, televisions, and monitors with an LCD, also directly infringe, either literally or under the doctrine of equivalents, under 35 U.S.C. § 271(a), the '973 patent by using, offering to sell, and/or selling to third party distributors or consumers (directly or through intermediaries and/or subsidiaries) in this District and elsewhere within the United States and/or importing into the United States, those infringing display products.~~

~~54. Upon information and belief, the third party manufacturers, distributors, and importers that sell display products to LG that include all of the limitations of one or more claims of the '973 patent, also directly infringe, either literally or under the doctrine of equivalents, under 35 U.S.C. § 271(a), the '973 patent by making, offering to sell, and/or selling (directly or through intermediaries and/or subsidiaries) infringing products in this District and elsewhere within the United States and/or importing infringing products into the United States.~~

~~55. Upon information and belief, LG had knowledge of the '973 patent and its infringing conduct at least since the filing of this amended complaint, when LG was formally placed on notice of its infringement.~~

~~56. Upon information and belief, since at least the above mentioned date when DDG formally placed LG on notice of its infringement, LG has actively induced, under U.S.C. § 271(b), third party manufacturers, distributors, importers and/or consumers that purchase or sell display products that include all of the limitations of one or more claims of the '973 patent, including but not limited to mobile phones, tablets, televisions, and monitors with an LCD, to directly infringe one or more claims of the '973 patent. Since at least the notice provided on the above mentioned date, LG does so with knowledge, or with willful blindness of the fact, that the induced acts constitute infringement of the '973 patent. Upon information and belief, LG intends to cause, and has taken affirmative steps to induce, infringement by these third party manufacturers, distributors,~~

~~importers, and/or consumers by, *inter alia*, creating advertisements that promote the infringing use of display products, creating established distribution channels for these products into and within the United States, purchasing these products, manufacturing these products in conformity with U.S. laws and regulations, distributing or making available instructions or manuals for these products to purchasers and prospective buyers, and/or providing technical support, replacement parts, or services for these products to these purchasers in the United States.~~

~~57. As a direct and proximate result of these acts of patent infringement, LG has encroached on the exclusive rights of DDG and its licensees to practice the '973 patent, for which DDG is entitled to at least a reasonable royalty.~~

~~COUNT IV~~

~~Patent Infringement of U.S. Patent No. 7,434,974~~

~~58.~~25. ~~Plaintiffs repeat and re-allege each and every allegation of paragraphs 1-57~~1-23 as though fully set forth herein.

~~59.~~26. The '974 patent is valid and enforceable.

~~60.~~27. LG has never been licensed, either expressly or impliedly, under the '974 patent.

~~61.~~28. Upon information and belief, to the extent any marking or notice was required by 35 U.S.C. § 287, IDT has complied with the requirements of that statute by providing actual or constructive notice to LG of its alleged infringement. Upon information and belief, IDT surmises that any express licensees of the '974 patent have complied with the marking requirements of 35 U.S.C. § 287 by placing a notice of the '974 patent on all goods made, offered for sale, sold within, and/or imported into the United States that embody one or more claims of that patent.

~~62.~~29. Upon information and belief, LG has been and is directly infringing under 35 U.S.C. § 271(a), either literally or under the doctrine of equivalents, and/or indirectly infringing, by way of inducement with specific intent under 35 U.S.C. § 271(b), the '974 patent by making,

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using, offering to sell, and/or selling to third-party distributors, and/or consumers (directly or through intermediaries and/or subsidiaries) in this District and elsewhere within the United States and/or importing into the United States, without authority, display products that include all of the limitations of one or more claims of the '974 patent, including but not limited to mobile phones, tablets, televisions, and monitors with an LCD, their display components, and/or other products made, used, sold, offered for sale, or imported by LG that include all of the limitations of one or more claims of the '974 patent.

~~63.~~30. Upon information and belief, distributors and consumers that purchase LG's display products that include all of the limitations of one or more claims of the '974 patent, including but not limited to mobile phones, tablets, televisions, and monitors with an LCD, also directly infringe, either literally or under the doctrine of equivalents, under 35 U.S.C. § 271(a), the '974 patent by using, offering to sell, and/or selling to third-party distributors or consumers (directly or through intermediaries and/or subsidiaries) in this District and elsewhere within the United States and/or importing into the United States, those infringing display products.

~~64.~~31. Upon information and belief, the third-party manufacturers, distributors, and importers that sell display products to LG that include all of the limitations of one or more claims of the '974 patent, also directly infringe, either literally or under the doctrine of equivalents, under 35 U.S.C. § 271(a), the '974 patent by making, offering to sell, and/or selling (directly or through intermediaries and/or subsidiaries) infringing products in this District and elsewhere within the United States and/or importing infringing products into the United States.

~~65.~~32. Upon information and belief, LG had knowledge of the '974 patent and its infringing conduct at least since ~~the filing of this lawsuit, when LG was formally placed on notice of its infringement~~January 30, 2013, and likely as early as April 23, 2012, as described below.

33. [redacted]

34. [redacted]

35. [redacted]

[redacted]

36. [redacted]

37. On June 28, 2013, Plaintiff IDT filed lawsuits against several parties in the Eastern District of Texas, alleging infringement of the '974 patent, including Dell Inc. ("Dell") and Hewlett-Packard Co. ("HP"). *Innovative Display Technologies LLC v. Dell, Inc.*, Case No. 2:13-cv-00523-RSP (E.D. Tex.); *Innovative Display Technologies LLC v. Hewlett-Packard Company*, Case No. 2:13-cv-00524-JRG-RSP (E.D. Tex.). On December 20, 2013, Plaintiff IDT served infringement contentions against Dell and HP for the '974 patent. Those contentions alleged infringement of the '974 patent based on some of the same display products that remain unlicensed and accused in this lawsuit (*e.g.*, LP133WH2-TLGA, LP156WH3-TLSA, LP156WH4-TLQ2). LG

publicly admitted that it was indemnifying Dell and HP in those lawsuits. On March 10, 2015, the lawsuits against Dell and HP were dismissed following a settlement agreement between the parties.

[redacted]

38. For many other lawsuits filed in the Eastern District of Texas and in the District of Delaware, Plaintiffs believe that LG is or was indemnifying or obligated to indemnify the defendants for infringement of the patents-in-suit based on LG supplying those defendants with infringing display products. Those lawsuits include, but are not limited to, the following:

(a) *Innovative Display Technologies LLC v. Acer Inc. et al.*, Case No. 2:13-cv-00522-JRG-RSP (E.D. Tex., filed 06/28/2013)

(b) *Innovative Display Technologies LLC v. Huawei Investment and Holding Co., Ltd. et al.*, Case No. 2:13-cv-00525-JRG (E.D. Tex., filed 06/28/2013)

(c) *Innovative Display Technologies LLC v BlackBerry Limited et al.*, Case No. 2:13-cv-00526-JRG (E.D. Tex., filed 06/28/2013)

(d) *Innovative Display Technologies LLC v. ZTE Corporation et al.*, *Case* No. 2:13-cv-00527-JRG (E.D. Tex., filed 06/28/2013)

(e) *Innovative Display Technologies LLC v. Nokia Corporation et al.*, Case No. 2:13-cv-00784-JRG (E.D. Tex., filed 10/01/2013)

(f) *Innovative Display Technologies LLC v. Apple Inc.*, Case No. 2:14-cv-00030-JRG (E.D. Tex., filed 01/17/2014)

(g) *Innovative Display Technologies LLC v. BMW of North America, LLC et al.*, Case No. 2:14-cv-00106-JRG (E.D. Tex., filed 02/21/2014)

(h) *Innovative Display Technologies LLC v. Toyota Motor Corporation et al.*, Case No. 2:14-cv-00200-JRG (E.D. Tex., filed 03/10/2014)

(i) *Innovative Display Technologies LLC v. Hyundai Motor Group et al.*, Case No. 2:14-cv-00201-JRG (E.D. Tex., filed 03/10/2014)

(j) *Innovative Display Technologies LLC v. Nissan Motor Co., Ltd. et al.*, Case No. 2:14-cv-00202-JRG (E.D. Tex., filed 03/10/2014)

(k) *Innovative Display Technologies LLC v. Volkswagen AG et al.*, Case No. 2:14-cv-00300-JRG (E.D. Tex., filed 04/07/2014)

(l) *Innovative Display Technologies LLC et al. v. Apple Inc.*, Case No. 2:14-cv-00301-JRG (E.D. Tex., filed 04/08/2014)

(m) *Innovative Display Technologies LLC v. Google Inc. et al.*, Case No. 2:14-cv-00302-JRG-RSP (E.D. Tex., filed 04/08/2014)

(n) *Innovative Display Technologies LLC v. Best Buy Co., Inc. et al.*, Case No. 2:14-cv-00532-JRG (E.D. Tex., filed 04/24/2014)

(o) *Innovative Display Technologies LLC v. Mercedes-Benz U.S. International, Inc. et al.*, Case No. 2:14-cv-00535-JRG (E.D. Tex., filed 04/24/2014)

(p) *Innovative Display Technologies LLC v. Mazda Motor Corporation et al.*, Case No. 2:14-cv-00624-JRG (E.D. Tex., filed 05/13/2014)

(q) *Delaware Display Group LLC et al. v. Amazon.com Inc.*, Case No. 1:13-cv-02106-RGA (D. Del., filed 12/31/2013)

(r) *Delaware Display Group LLC et al. v. HTC Corporation et al.*, Case No. 1:13-cv-02107-RGA (D. Del., filed 12/31/2013)

(s) *Delaware Display Group LLC et al. v. Lenovo Holding Company Inc. et al.*, Case No. 1:13-cv-02108-RGA (D. Del., filed 12/31/2013)

(t) *Delaware Display Group LLC et al. v. Sony Corporation et al.*, Case No. 1:13-cv-02111-RGA (D. Del. , filed 12/31/2013)

(u) *Innovative Display Technologies LLC v. Ford Motor Company*, Case No. 1:14-cv-00849-RGA (D. Del., filed 06/30/2014)

(v) *Innovative Display Technologies LLC v. General Motors* LLC, Case No. 1:14-cv-00850-RGA (D. Del. , filed 06/30/2014)

39. On December 31, 2013, Plaintiffs filed their original complaint against LG in this case, asserting infringement of the '974 patent. In discovery in this case, LG has admitted that it had knowledge of the '974 patent prior to the filing of that original complaint. Plaintiffs identified their initial list of accused LG products on August 22, 2014. Plaintiffs served LG with preliminary infringement contentions on November 21, 2014. Plaintiffs amended their list of accused display products against LG on March 30, 2015. On October 14, 2015, Plaintiffs served supplemental infringement contentions on LG.

40. On July 1, 2014, LG filed an *inter partes* review ("IPR") petition with the Patent Trial and Appeal Board ("PTAB") against the '974 patent (IPR2014-01092). On January 13, 2015, the PTAB denied institution of that IPR. On March 9, 2015, the PTAB denied LG's request for a rehearing on the decision to deny institution of that IPR. On December 29, 2014, LG filed another IPR petition (IPR2015-00497) against the '974 patent. The PTAB denied institution of that petition on July 15, 2015. None of LG's *inter partes* review petitions against the '974 patent has been instituted.

41. LG's acts of infringement of the '974 patent have been willful and intentional. Since at least the above-mentioned date of notice, LG has acted with an objectively high likelihood that its actions constituted infringement of the '974 patent by refusing to take a license and continuing to make, sell, and import display products that include all of the limitations of one or more claims of the '974 patent, and the objectively-defined risk of infringement was either known or so obvious that it should have been known. LG has known about the '974 patent since as least as early as January 30, 2013. LG has been aware that it infringes the '974 patent since at least then; LG has participated in many lawsuits involving the '974 patent since then. LG has failed in its several attempts to have the '974 patent invalidated by *inter partes* review. Instead of taking a license during that time, LG has opted to make the business decision to "efficiently infringe" the '974 patent. In doing so, LG has willfully infringed the patents-in-suit.

~~66.~~42. Upon information and belief, since at least the above-mentioned date when IDT formally placed LG on notice of its infringement, LG has actively induced, under U.S.C. § 271(b), third-party manufacturers, distributors, importers and/or consumers that purchase or sell display products that include all of the limitations of one or more claims of the '974 patent, including but not limited to mobile phones, tablets, televisions, and monitors with an LCD, to directly infringe one or more claims of the '974 patent. Since at least the notice provided on the above-mentioned date, LG does so with knowledge, or with willful blindness of the fact, that the induced acts constitute infringement of the '974 patent. Upon information and belief, LG intends to cause, and has taken affirmative steps to induce, infringement by these third-party manufacturers, distributors, importers, and/or consumers by, *inter alia*, creating advertisements that promote the infringing use of display products, creating established distribution channels for these products into and within the United States, purchasing these products, manufacturing these products in conformity with

U.S. laws and regulations, distributing or making available instructions or manuals for these products to purchasers and prospective buyers, and/or providing technical support, replacement parts, or services for these products to these purchasers in the United States.

~~67.~~43. As a direct and proximate result of these acts of patent infringement, LG has encroached on the exclusive rights of IDT and its licensees to practice the '974 patent, for which IDT is entitled to at least a reasonable royalty.

COUNT ~~VI~~II

Patent Infringement of U.S. Patent No. 7,537,370

~~68.~~44. Plaintiffs repeat and re-allege each and every allegation of paragraphs ~~1-67~~1-43 as though fully set forth herein.

~~69.~~45. The '370 patent is valid and enforceable.

~~70.~~46. LG has never been licensed, either expressly or impliedly, under the '370 patent.

~~71.~~47. Upon information and belief, to the extent any marking or notice was required by 35 U.S.C. § 287, IDT has complied with the requirements of that statute by providing actual or constructive notice to LG of its alleged infringement. Upon information and belief, IDT surmises that any express licensees of the '370 patent have complied with the marking requirements of 35 U.S.C. § 287 by placing a notice of the '370 patent on all goods made, offered for sale, sold within, and/or imported into the United States that embody one or more claims of that patent.

~~72.~~48. Upon information and belief, LG has been and is directly infringing under 35 U.S.C. § 271(a), either literally or under the doctrine of equivalents, and/or indirectly infringing, by way of inducement with specific intent under 35 U.S.C. § 271(b), the '370 patent by making, using, offering to sell, and/or selling to third-party distributors, and/or consumers (directly or through intermediaries and/or subsidiaries) in this District and elsewhere within the United States and/or importing into the United States, without authority, display products that include all of the

limitations of one or more claims of the ’370 patent, including but not limited to mobile phones, tablets, televisions, and monitors with an LCD, their display components, and/or other products made, used, sold, offered for sale, or imported by LG that include all of the limitations of one or more claims of the’370 patent.

~~73.~~49. Upon information and belief, distributors and consumers that purchase LG’s display products that include all of the limitations of one or more claims of the ’370 patent, including but not limited to mobile phones, tablets, televisions, and monitors with an LCD, also directly infringe, either literally or under the doctrine of equivalents, under 35 U.S.C. § 271(a), the ’370 patent by using, offering to sell, and/or selling to third-party distributors or consumers (directly or through intermediaries and/or subsidiaries) in this District and elsewhere within the United States and/or importing into the United States, those infringing display products.

~~74.~~50. Upon information and belief, the third-party manufacturers, distributors, and importers that sell display products to LG that include all of the limitations of one or more claims of the ’370 patent, also directly infringe, either literally or under the doctrine of equivalents, under 35 U.S.C. § 271(a), the ’370 patent by making, offering to sell, and/or selling (directly or through intermediaries and/or subsidiaries) infringing products in this District and elsewhere within the United States and/or importing infringing products into the United States.

51. Upon information and belief, LG had knowledge of the ’370 patent and its infringing conduct at least since ~~the filing of this lawsuit, when LG was formally placed on notice of its infringement.~~January 30, 2013, and likely as early as April 23, 2012, as described below.

52. [redacted]

[redacted].

53. [redacted]

54. [redacted].

55. [redacted]

56. On June 28, 2013, Plaintiff IDT filed lawsuits against several parties in the Eastern District of Texas, alleging infringement of the '370 patent, including Dell and HP. *Innovative Display Technologies LLC v. Dell, Inc.*, Case No. 2:13-cv-00523-RSP (E.D. Tex.); *Innovative Display Technologies LLC v. Hewlett-Packard Company*, Case No. 2:13-cv-00524-JRG-RSP (E.D. Tex.). On December 20, 2013, Plaintiff IDT served infringement contentions against Dell and HP for the '370 patent. Those contentions alleged infringement of the '370 patent based on some of the same display products that remain unlicensed and accused in this lawsuit (*e.g.*, LP156WH3-TLSA, LP156WH4-TLQ2). LG publicly admitted that it was indemnifying Dell and HP in those lawsuits. On March 10, 2015, the lawsuits against Dell and HP were dismissed following a settlement agreement between the parties. [redacted]

57. For many other lawsuits filed in the Eastern District of Texas and in the District of Delaware, Plaintiffs believe that LG is or was indemnifying or obligated to indemnify the defendants for infringement of the patents-in-suit based on LG supplying those defendants with infringing display products. Those lawsuits include, but are not limited to, the following:

(a) *Innovative Display Technologies LLC v. Acer Inc. et al.*, Case No. 2:13-cv-00522-JRG-RSP (E.D. Tex., filed 06/28/2013)

(b) *Innovative Display Technologies LLC v. Huawei Investment and Holding Co., Ltd. et al.*, Case No. 2:13-cv-00525-JRG (E.D. Tex., filed 06/28/2013)

(c) *Innovative Display Technologies LLC v BlackBerry Limited et al.*, Case No. 2:13-cv-00526-JRG (E.D. Tex., filed 06/28/2013)

(d) *Innovative Display Technologies LLC v. ZTE Corporation et al., Case* No. 2:13-cv-00527-JRG (E.D. Tex., filed 06/28/2013)

(e) *Innovative Display Technologies LLC v. Nokia Corporation et al.*, Case No. 2:13-cv-00784-JRG (E.D. Tex., filed 10/01/2013)

(f) *Innovative Display Technologies LLC v. Apple Inc.*, Case No. 2:14-cv-00030-JRG (E.D. Tex., filed 01/17/2014)

(g) *Innovative Display Technologies LLC v. BMW of North America, LLC et al.*, Case No. 2:14-cv-00106-JRG (E.D. Tex., filed 02/21/2014)

(h) *Innovative Display Technologies LLC v. Toyota Motor Corporation et al.*, Case No. 2:14-cv-00200-JRG (E.D. Tex., filed 03/10/2014)

(i) *Innovative Display Technologies LLC v. Hyundai Motor Group et al.*, Case No. 2:14-cv-00201-JRG (E.D. Tex., filed 03/10/2014)

(j) *Innovative Display Technologies LLC v. Nissan Motor Co., Ltd. et al.*, Case No. 2:14-cv-00202-JRG (E.D. Tex., filed 03/10/2014)

(k) *Innovative Display Technologies LLC v. Volkswagen AG et al.*, Case No. 2:14-cv-00300-JRG (E.D. Tex., filed 04/07/2014)

(l) *Innovative Display Technologies LLC et al. v. Apple Inc.*, Case No. 2:14-cv-00301-JRG (E.D. Tex., filed 04/08/2014)

(m) *Innovative Display Technologies LLC v. Google Inc. et al.*, Case No. 2:14-cv-00302-JRG-RSP (E.D. Tex., filed 04/08/2014)

(n) *Innovative Display Technologies LLC v. Best Buy Co., Inc. et al.*, Case No. 2:14-cv-00532-JRG (E.D. Tex., filed 04/24/2014)

(o) *Innovative Display Technologies LLC v. Mercedes-Benz U.S. International, Inc. et al.*, Case No. 2:14-cv-00535-JRG (E.D. Tex., filed 04/24/2014)

(p) *Innovative Display Technologies LLC v. Mazda Motor Corporation et al.*, Case No. 2:14-cv-00624-JRG (E.D. Tex., filed 05/13/2014)

(q) *Delaware Display Group LLC et al. v. Amazon.com Inc.*, Case No. 1:13-cv-02106-RGA (D. Del., filed 12/31/2013)

(r) *Delaware Display Group LLC et al. v. HTC Corporation et al.*, Case No. 1:13-cv-02107-RGA (D. Del., filed 12/31/2013)

(s) *Delaware Display Group LLC et al. v. Lenovo Holding Company Inc. et al.*, Case No. 1:13-cv-02108-RGA (D. Del., filed 12/31/2013)

(t) *Delaware Display Group LLC et al. v. Sony Corporation et al.*, Case No. 1:13-cv-02111-RGA (D. Del. , filed 12/31/2013)

(u) *Innovative Display Technologies LLC v. Ford Motor Company*, Case No. 1:14-cv-00849-RGA (D. Del., filed 06/30/2014)

(v) *Innovative Display Technologies LLC v. General Motors* LLC, Case No. 1:14-cv-00850-RGA (D. Del. , filed 06/30/2014).

58. On December 31, 2013, Plaintiffs filed their original complaint against LG in this case, asserting infringement of the '370 patent. In discovery in this case, LG has admitted that it had knowledge of the '370 patent prior to the filing of that original complaint. Plaintiffs identified their initial list of accused LG products on August 22, 2014. Plaintiffs served LG with preliminary infringement contentions on November 21, 2014. Plaintiffs amended their list of accused display products against LG on March 30, 2015. On October 14, 2015, Plaintiffs served supplemental infringement contentions on LG.

59. On July 1, 2014, LG filed an IPR petition with the PTAB against the '370 patent (IPR2014-01096). On January 13, 2015, the PTAB instituted that IPR for only claims 15 and 27 – neither of which are asserted in this case. The PTAB declined to institute IPR2014-01096 against the '370 patent for any of the claims asserted in this case. On March 9, 2015, the PTAB denied LG's request for a rehearing on the decision to deny institution of that IPR for the asserted claims in this case. On December 29, 2014, LG filed another IPR petition (IPR2015-00493) against the '370 patent. The result was the same as for IPR2014-01096 – none of the asserted claims in this case was instituted. Thus, for the asserted claims in this lawsuit, none of LG's *inter partes* review petitions against the '370 patent has been instituted.

~~75.~~60. LG's acts of infringement of the '370 patent have been willful and intentional. Since at least the above-mentioned date of notice, LG has acted with an objectively high likelihood that its actions constituted infringement of the '370 patent by refusing to take a license and

continuing to make, sell, and import display products that include all of the limitations of one or more claims of the '370 patent, and the objectively-defined risk of infringement was either known or so obvious that it should have been known. LG has known about the '370 patent since as least as early as January 30, 2013. LG has been aware that it infringes the '370 patent since at least then; LG has participated in many lawsuits involving the '370 patent since then. LG has failed in its several attempts to have the asserted claims of the '370 patent invalidated by *inter partes* review. Instead of taking a license during that time, LG has opted to make the business decision to "efficiently infringe" the '370 patent. In doing so, LG has willfully infringed the patents-in-suit.

~~76.~~61. Upon information and belief, since at least the above-mentioned date when IDT formally placed LG on notice of its infringement, LG has actively induced, under U.S.C. § 271(b), third-party manufacturers, distributors, importers and/or consumers that purchase or sell display products that include all of the limitations of one or more claims of the '370 patent, including but not limited to mobile phones, tablets, televisions, and monitors with an LCD, to directly infringe one or more claims of the '370 patent. Since at least the notice provided on the above-mentioned date, LG does so with knowledge, or with willful blindness of the fact, that the induced acts constitute infringement of the '370 patent. Upon information and belief, LG intends to cause, and has taken affirmative steps to induce, infringement by these third-party manufacturers, distributors, importers, and/or consumers by, *inter alia*, creating advertisements that promote the infringing use of display products, creating established distribution channels for these products into and within the United States, purchasing these products, manufacturing these products in conformity with U.S. laws and regulations, distributing or making available instructions or manuals for these products to purchasers and prospective buyers, and/or providing technical support, replacement parts, or services for these products to these purchasers in the United States.

~~77.~~62. As a direct and proximate result of these acts of patent infringement, LG has encroached on the exclusive rights of IDT and its licensees to practice the '370 patent, for which IDT is entitled to at least a reasonable royalty.

COUNT ~~VIII~~

Patent Infringement of U.S. Patent No. 7,914,196

~~78.~~63. Plaintiffs repeat and re-allege each and every allegation of paragraphs ~~1-77~~1-62 as though fully set forth herein.

~~79.~~64. The '196 patent is valid and enforceable.

~~80.~~65. LG has never been licensed, either expressly or impliedly, under the '196 patent.

~~81.~~66. Upon information and belief, to the extent any marking or notice was required by 35 U.S.C. § 287, DDG has complied with the requirements of that statute by providing actual or constructive notice to LG of its alleged infringement. Upon information and belief, DDG surmises that any express licensees of the '196 patent have complied with the marking requirements of 35 U.S.C. § 287 by placing a notice of the '196 patent on all goods made, offered for sale, sold within, and/or imported into the United States that embody one or more claims of that patent.

~~82.~~67. Upon information and belief, LG has been and is directly infringing under 35 U.S.C. § 271(a), either literally or under the doctrine of equivalents, and/or indirectly infringing, by way of inducement with specific intent under 35 U.S.C. § 271(b), the '196 patent by making, using, offering to sell, and/or selling to third-party distributors, and/or consumers (directly or through intermediaries and/or subsidiaries) in this District and elsewhere within the United States and/or importing into the United States, without authority, display products that include all of the limitations of one or more claims of the '196 patent, including but not limited to mobile phones, tablets, televisions, and monitors with an LCD, their display components, and/or other products

made, used, sold, offered for sale, or imported by LG that include all of the limitations of one or more claims of the '196 patent.

~~83.~~68. Upon information and belief, distributors and consumers that purchase LG's display products that include all of the limitations of one or more claims of the '196 patent, including but not limited to mobile phones, tablets, televisions, and monitors with an LCD, also directly infringe, either literally or under the doctrine of equivalents, under 35 U.S.C. § 271(a), the '196 patent by using, offering to sell, and/or selling to third-party distributors or consumers (directly or through intermediaries and/or subsidiaries) in this District and elsewhere within the United States and/or importing into the United States, those infringing display products.

~~84.~~69. Upon information and belief, the third-party manufacturers, distributors, and importers that sell display products to LG that include all of the limitations of one or more claims of the '196 patent, also directly infringe, either literally or under the doctrine of equivalents, under 35 U.S.C. § 271(a), the '196 patent by making, offering to sell, and/or selling (directly or through intermediaries and/or subsidiaries) infringing products in this District and elsewhere within the United States and/or importing infringing products into the United States.

~~85.~~70. Upon information and belief, LG had knowledge of the '196 patent and its infringing conduct at least since ~~the filing of this lawsuit, when LG was formally placed on notice of its infringement~~January 30, 2013, and likely as early as April 23, 2012, as described below.

71. [redacted]

[redacted]

72. [redacted]

73. [redacted]

74. [redacted]

[redacted]

75. On December 31, 2013, Plaintiffs filed their original complaint against LG in this case, asserting infringement of the '196 patent. Plaintiffs identified their initial list of accused LG products on August 22, 2014. Plaintiffs served LG with preliminary infringement contentions on November 21, 2014. Plaintiffs amended their list of accused display products against LG on March 30, 2015. On October 14, 2015, Plaintiffs served supplemental infringement contentions on LG.

76. On August 21, 2014, LG filed an IPR petition with the PTAB against the '196 patent (IPR2014-01359). On March 2, 2015, the PTAB declined to institute IPR2014-01359 against the '196 patent. On December 29, 2014, LG filed another IPR petition (IPR2015-00492) against the '196 patent. The PTAB declined to institute IPR2015-00492 against the '196 patent. Thus, none of LG's *inter partes* review petitions against the '196 patent has been instituted.

77. LG's acts of infringement of the '196 patent have been willful and intentional. Since at least the above-mentioned date of notice, LG has acted with an objectively high likelihood that its actions constituted infringement of the '196 patent by refusing to take a license and continuing to make, sell, and import display products that include all of the limitations of one or

more claims of the '196 patent, and the objectively-defined risk of infringement was either known or so obvious that it should have been known. LG has known about the '196 patent since as least as early as January 30, 2013. LG has been aware that it infringes the '196 patent since at least then. LG has failed in its several attempts to have the asserted claims of the '196 patent invalidated by *inter partes* review. Instead of taking a license during that time, LG has opted to make the business decision to "efficiently infringe" the '196 patent. In doing so, LG has willfully infringed the patents-in-suit.

~~86.~~78. Upon information and belief, since at least the above-mentioned date when DDG formally placed LG on notice of its infringement, LG has actively induced, under U.S.C. § 271(b), third-party manufacturers, distributors, importers and/or consumers that purchase or sell display products that include all of the limitations of one or more claims of the '196 patent, including but not limited to mobile phones, tablets, televisions, and monitors with an LCD, to directly infringe one or more claims of the '196 patent. Since at least the notice provided on the above-mentioned date, LG does so with knowledge, or with willful blindness of the fact, that the induced acts constitute infringement of the '196 patent. Upon information and belief, LG intends to cause, and has taken affirmative steps to induce, infringement by these third-party manufacturers, distributors, importers, and/or consumers by, *inter alia*, creating advertisements that promote the infringing use of display products, creating established distribution channels for these products into and within the United States, purchasing these products, manufacturing these products in conformity with U.S. laws and regulations, distributing or making available instructions or manuals for these products to purchasers and prospective buyers, and/or providing technical support, replacement parts, or services for these products to these purchasers in the United States.

~~87.~~79. As a direct and proximate result of these acts of patent infringement, LG has encroached on the exclusive rights of DDG and its licensees to practice the '196 patent, for which DDG is entitled to at least a reasonable royalty.

~~COUNT VII~~

~~Patent Infringement of U.S. Patent No.~~ COUNT IV

Patent Infringement of U.S. Patent No. 8,215,816

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~~88.~~80. Plaintiffs repeat and re-allege each and every allegation of paragraphs ~~1-87~~1-79 as though fully set forth herein.

~~89.~~81. The '816 patent is valid and enforceable.

~~90.~~82. LG has never been licensed, either expressly or impliedly, under the '816 patent.

~~91.~~83. Upon information and belief, to the extent any marking or notice was required by 35 U.S.C. § 287, IDT has complied with the requirements of that statute by providing actual or constructive notice to LG of its alleged infringement. Upon information and belief, IDT surmises that any express licensees of the '816 patent have complied with the marking requirements of 35 U.S.C. § 287 by placing a notice of the '816 patent on all goods made, offered for sale, sold within, and/or imported into the United States that embody one or more claims of that patent.

~~92.~~84. Upon information and belief, LG has been and is directly infringing under 35 U.S.C. § 271(a), either literally or under the doctrine of equivalents, and/or indirectly infringing, by way of inducement with specific intent under 35 U.S.C. § 271(b), the '816 patent by making, using, offering to sell, and/or selling to third-party distributors, and/or consumers (directly or through intermediaries and/or subsidiaries) in this District and elsewhere within the United States and/or importing into the United States, without authority, display products that include all of the limitations of one or more claims of the '816 patent, including but not limited to mobile phones,

tablets, televisions, and monitors with an LCD, their display components, and/or other products made, used, sold, offered for sale, or imported by LG that include all of the limitations of one or more claims of the '816 patent.

~~93.~~85. Upon information and belief, distributors and consumers that purchase LG's display products that include all of the limitations of one or more claims of the '816 patent, including but not limited to mobile phones, tablets, televisions, and monitors with an LCD, also directly infringe, either literally or under the doctrine of equivalents, under 35 U.S.C. § 271(a), the '816 patent by using, offering to sell, and/or selling to third-party distributors or consumers (directly or through intermediaries and/or subsidiaries) in this District and elsewhere within the United States and/or importing into the United States, those infringing display products.

~~94.~~86. Upon information and belief, the third-party manufacturers, distributors, and importers that sell display products to LG that include all of the limitations of one or more claims of the '816 patent, also directly infringe, either literally or under the doctrine of equivalents, under 35 U.S.C. § 271(a), the '816 patent by making, offering to sell, and/or selling (directly or through intermediaries and/or subsidiaries) infringing products in this District and elsewhere within the United States and/or importing infringing products into the United States.

87. Upon information and belief, LG had knowledge of the '816 patent and its infringing conduct at least since February 8, 2013, and likely as early as the ~~filing~~issuance of ~~this lawsuit, when LG was formally placed on~~ the '816 patent, as described below.

88. [redacted]

[redacted]

89. [redacted]

90. [redacted]

91. On June 28, 2013, Plaintiff IDT filed lawsuits against several parties in the Eastern District of Texas, alleging infringement of the '816 patent, including Dell and HP. *Innovative Display Technologies LLC v. Dell, Inc.*, Case No. 2:13-cv-00523-RSP (E.D. Tex.); *Innovative Display Technologies LLC v. Hewlett-Packard Company*, Case No. 2:13-cv-00524-JRG-RSP (E.D. Tex.). On December 20, 2013, Plaintiff IDT served infringement contentions against Dell and HP for the '816 patent. Those contentions alleged infringement of the '816 patent based on some of the same display products that remain unlicensed and accused in this lawsuit (*e.g.*, LP133WH2-TLGA, LP156WH3-TLSA, LP156WH4-TLQ2). LG publicly admitted that it was indemnifying Dell and HP in those lawsuits. On March 10, 2015, the lawsuits against Dell and HP were dismissed following a settlement agreement between the parties. [redacted]

92. For many other lawsuits filed in the Eastern District of Texas and in the District of Delaware, Plaintiffs believe that LG is or was indemnifying or obligated to indemnify the defendants for infringement of the patents-in-suit based on LG supplying those defendants with infringing display products. Those lawsuits include, but are not limited to, the following:

(a) *Innovative Display Technologies LLC v. Acer Inc. et al.*, Case No. 2:13-cv-00522-JRG-RSP (E.D. Tex., filed 06/28/2013)

(b) *Innovative Display Technologies LLC v. Huawei Investment and Holding Co., Ltd. et al.*, Case No. 2:13-cv-00525-JRG (E.D. Tex., filed 06/28/2013)

(c) *Innovative Display Technologies LLC v BlackBerry Limited et al.*, Case No. 2:13-cv-00526-JRG (E.D. Tex., filed 06/28/2013)

(d) *Innovative Display Technologies LLC v. ZTE Corporation et al.*, *Case* No. 2:13-cv-00527-JRG (E.D. Tex., filed 06/28/2013)

(e) *Innovative Display Technologies LLC v. Nokia Corporation et al.*, Case No. 2:13-cv-00784-JRG (E.D. Tex., filed 10/01/2013)

(f) *Innovative Display Technologies LLC v. Apple Inc.*, Case No. 2:14-cv-00030-JRG (E.D. Tex., filed 01/17/2014)

(g) *Innovative Display Technologies LLC v. BMW of North America, LLC et al.*, Case No. 2:14-cv-00106-JRG (E.D. Tex., filed 02/21/2014)

(h) *Innovative Display Technologies LLC v. Toyota Motor Corporation et al.*, Case No. 2:14-cv-00200-JRG (E.D. Tex., filed 03/10/2014)

(i) *Innovative Display Technologies LLC v. Hyundai Motor Group et al.*, Case No. 2:14-cv-00201-JRG (E.D. Tex., filed 03/10/2014)

(j) *Innovative Display Technologies LLC v. Nissan Motor Co., Ltd. et al.*, Case No. 2:14-cv-00202-JRG (E.D. Tex., filed 03/10/2014)

(k) *Innovative Display Technologies LLC v. Volkswagen AG et al.*, Case No. 2:14-cv-00300-JRG (E.D. Tex., filed 04/07/2014)

(l) *Innovative Display Technologies LLC et al. v. Apple Inc.*, Case No. 2:14-cv-00301-JRG (E.D. Tex., filed 04/08/2014)

(m) *Innovative Display Technologies LLC v. Google Inc. et al.*, Case No. 2:14-cv-00302-JRG-RSP (E.D. Tex., filed 04/08/2014)

(n) *Innovative Display Technologies LLC v. Best Buy Co., Inc. et al.*, Case No. 2:14-cv-00532-JRG (E.D. Tex., filed 04/24/2014)

(o) *Innovative Display Technologies LLC v. Mercedes-Benz U.S. International, Inc. et al.*, Case No. 2:14-cv-00535-JRG (E.D. Tex., filed 04/24/2014)

(p) *Innovative Display Technologies LLC v. Mazda Motor Corporation et al.*, Case No. 2:14-cv-00624-JRG (E.D. Tex., filed 05/13/2014)

(q) *Delaware Display Group LLC et al. v. Amazon.com Inc.*, Case No. 1:13-cv-02106-RGA (D. Del., filed 12/31/2013)

(r) *Delaware Display Group LLC et al. v. HTC Corporation et al.*, Case No. 1:13-cv-02107-RGA (D. Del., filed 12/31/2013)

(s) *Delaware Display Group LLC et al. v. Lenovo Holding Company Inc. et al.*, Case No. 1:13-cv-02108-RGA (D. Del., filed 12/31/2013)

(t) *Delaware Display Group LLC et al. v. Sony Corporation et al.*, Case No. 1:13-cv-02111-RGA (D. Del. , filed 12/31/2013)

(u) *Innovative Display Technologies LLC v. Ford Motor Company*, Case No. 1:14-cv-00849-RGA (D. Del., filed 06/30/2014)

(v) *Innovative Display Technologies LLC v. General Motors* LLC, Case No. 1:14-cv-00850-RGA (D. Del. , filed 06/30/2014).

93. On December 31, 2013, Plaintiffs filed their original complaint against LG in this case, asserting infringement of the ’816 patent. Plaintiffs identified their initial list of accused LG products on August 22, 2014. Plaintiffs served LG with preliminary infringement contentions on November 21, 2014. Plaintiffs amended their list of accused display products against LG on March 30, 2015. On October 14, 2015, Plaintiffs served supplemental infringement contentions on LG.

94. On July 1, 2014, LG filed an IPR petition with the PTAB against the ’816 patent (IPR2014-01095). On January 13, 2015, the PTAB denied institution of that IPR. On December 29, 2014, LG filed another IPR petition (IPR2015-00496) against the ’816 patent. The PTAB

denied institution of that petition on July 20, 2015. None of LG's *inter partes* review petitions against the '816 patent has been instituted.

95. LG's acts of infringement of the '816 patent have been willful and intentional. Since at least the above-mentioned date of notice, LG has acted with an objectively high likelihood that its actions constituted infringement of the '816 patent by refusing to take a license and continuing to make, sell, and import display products that include all of the limitations of one or more claims of the '816 patent, and the objectively-defined risk of infringement was either known or so obvious that it should have been known. LG has known about the '816 patent since as least as early as February 8, 2013. LG has been aware that it infringes the '816 patent since at least then; LG has participated in many lawsuits involving the '816 patent since then. LG has failed in its several attempts to have the asserted claims of the '816 patent invalidated by *inter partes* review. Instead of taking a license during that time, LG has opted to make the business decision to "efficiently infringe" the '816 patent. In doing so, LG has willfully infringed the patents-in-suit.

96. Upon information and belief, since at least the above-mentioned date when IDT formally placed LG on notice of its infringement, LG has actively induced, under U.S.C. § 271(b), third-party manufacturers, distributors, importers and/or consumers that purchase or sell display products that include all of the limitations of one or more claims of the '816 patent, including but not limited to mobile phones, tablets, televisions, and monitors with an LCD, to directly infringe one or more claims of the '816 patent. Since at least the notice provided on the above-mentioned date, LG does so with knowledge, or with willful blindness of the fact, that the induced acts constitute infringement of the '816 patent. Upon information and belief, LG intends to cause, and has taken affirmative steps to induce, infringement by these third-party manufacturers, distributors, importers, and/or consumers by, *inter alia*, creating advertisements that promote the infringing use

of display products, creating established distribution channels for these products into and within the United States, purchasing these products, manufacturing these products in conformity with U.S. laws and regulations, distributing or making available instructions or manuals for these products to purchasers and prospective buyers, and/or providing technical support, replacement parts, or services for these products to these purchasers in the United States.

97. As a direct and proximate result of these acts of patent infringement, LG has encroached on the exclusive rights of IDT and its licensees to practice the '816 patent, for which IDT is entitled to at least a reasonable royalty.

CONCLUSION

98. Plaintiffs are entitled to recover from LG the damages sustained by Plaintiffs as a result of LG's wrongful acts in an amount subject to proof at trial, which, by law, cannot be less than a reasonable royalty, together with interest and costs as fixed by this Court.

99. Plaintiffs have incurred and will incur attorneys' fees, costs, and expenses in the prosecution of this action. The circumstances of this dispute create an exceptional case within the meaning of 35 U.S.C. § 285, and Plaintiffs are entitled to recover their reasonable and necessary attorneys' fees, costs, and expenses.

JURY DEMAND

100. Plaintiffs hereby request a trial by jury pursuant to Rule 38 of the Federal Rules of Civil Procedure.

PRAYER FOR RELIEF

101. Plaintiffs respectfully request that the Court find in its favor and against LG, and that the Court grant Plaintiffs the following relief:

A. A judgment that LG has infringed the patents-in-suit as alleged herein, directly and/or indirectly by way of inducing infringement of such patents;

B. A judgment for an accounting of all damages sustained by Plaintiffs as a result of the acts of infringement by LG;

C. A judgment and order requiring LG to pay Plaintiffs damages under 35 U.S.C. § 284, including up to treble damages for willful infringement as provided by 35 U.S.C. § 284, and any royalties determined to be appropriate;

D. A permanent injunction enjoining LG and its officers, directors, agents, servants, employees, affiliates, divisions, branches, subsidiaries, parents and all others acting in concert or privity with them from direct and/or indirect infringement of the patents-in-suit pursuant to 35 U.S.C. § 283;

E. A judgment and order requiring LG to pay Plaintiffs pre-judgment and post-judgment interest on the damages awarded;

F. A judgment and order finding this to be an exceptional case and requiring LG to pay the costs of this action (including all disbursements) and attorneys' fees as provided by 35 U.S.C. § 285; and

G. Such other and further relief as the Court deems just and equitable.

Dated: ~~May~~December 4, 2015

Respectfully submitted,

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